CCRIF SPC
The Caribbean Catastrophe Risk Insurance Facility

Caribbean Regional Technical Workshop on CCRIF Models

Session 9:
Country Risk Profiles

With financial support from the European Union in the framework of the Caribbean Regional Resilience Building Facility, managed by the Global Facility for Disaster Reduction and Recovery (GFDRR)

CARIBBEAN REGIONAL RESILIENCE BUILDING FACILITY
A partnership funded by EUROPEAN UNION
GFDRR Global Facility for Disaster Reduction and Recovery
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Introduction to the Country Risk Profiles

AIM OF THE CRPs

- ✓ **Provide information to the Country Risk Managers with simplicity, accuracy and robustness** about the demographic, geological, economic characteristics of their territories
- ✓ **Assess the impact of historical events** which may have caused damages to infrastructure, population and economy
- ✓ **Illustrate and facilitate the risk transfer decisions**
- ✓ **Help decision-making process**, but not substitute it. Country risk managers have to decide what is best for the country, given the combination of exposure to risk, risk susceptibility and also considering budgeting restrictions

Introduction to the Country Risk Profiles

CONTENT OF THE CRPs

- ✓ Introduction to CCRIF and Country Risk Profile
- ✓ Overview of the Country
- ✓ Hazard (TC, EQ, XSR)
- ✓ Exposure
- ✓ Vulnerability
- ✓ Historical Losses (Annex 2 presents additional information)
- ✓ Risk
- ✓ CCRIF model summary (Annex 1 presents additional information)

Introduction to the Country Risk Profiles

Introduction to the Country Risk Profiles

The CCRIF Tropical Cyclone Model

SPHERA: System for Probabilistic Hazard Evaluation and Risk Assessment

CCRIF SPC offers parametric insurance products that provide coverage for tropical cyclones, earthquakes and excess rainfall. These products were designed to limit the financial impact of catastrophic tropical cyclones, earthquakes and extreme rainfall events on Caribbean and Central American governments by quickly providing short-term liquidity when a policy is triggered.

Starting in the 2019/20 policy year, the new tropical cyclone (TC) loss assessment model called SPHERA will replace the current model used by CCRIF – the Multi-hazard Parallel Risk Evaluation System (MPRES). The new SPHERA TC model is able to:

- Produce a probabilistic assessment of tropical cyclone risk, measured in terms of likelihood of TC-induced losses, to be used for parametric insurance policy pricing
- Estimate in near real time the damages to buildings and infrastructure due to TC-induced wind and storm surge caused by events in the region.
- Compute the payout to the insured countries due to the occurrence of a tropical cyclone according to the event parameters defined by the United States National Oceanic and Atmospheric Administration (NOAA).

- Probabilistic mode: the aim is to estimate the impact of tropical cyclones, either by-passing or making landfall on any of the countries in the region. A probabilistic procedure was adopted to generate stochastic storm tracks along with relevant parameters and for each track to compute wind and storm surge fields.
- Hindcasting mode: the aim is to compute wind and storm surge intensities induced by the occurrence of a tropical cyclone in near real time, according to the parameters provided by NOAA.

To accomplish the above requirements an updated historical catalogue of tropical cyclones was compiled to statistically characterize the event frequency and the parameters of storm events in the Central American (both Atlantic and Pacific coasts) and Caribbean regions and the most up-to-date and adequate wind field and storm surge prediction models were selected to estimate their intensities.

Historical catalogue

An updated historical tropical cyclone catalogue was compiled to statistically estimate the frequency of occurrence of future events and their characteristics. The catalogue was built by collecting historical and instrumental information for the events that originated in the Central American (again both Atlantic and Pacific coasts) and Caribbean regions since 1850.

Introduction to the Country Risk Profiles

The CCRIF Tropical Cyclone Model

SPHERA: System for Probabilistic Hazard Evaluation and Risk Assessment

Caribbean and Central American countries face a number of natural risks which will almost certainly be exacerbated in the future by climate change. Among other impacts, climate change is expected to produce more intense hurricanes, and this is likely to cause increased damage to public and private assets such as infrastructure and buildings, accelerating the erosion of coastal beaches, flooding low-lying land and triggering the loss of protective mangroves.

CCRIF SPC offers parametric insurance products that provide coverage for tropical cyclones, earthquakes and hazard Parallel Risk Evaluation System (MPRES). MPRES currently underpins the TC and EQ insurance products purchased by Caribbean and Central American countries.

The new SPHERA loss assessment models employ the most up-to-date datasets and techniques. The new SPHERA TC model is able to:

- Produce a probabilistic assessment of tropical cyclones risk, measured in terms of likelihood of TC-induced losses, to be used for parametric insurance policy pricing.

Introduction to the Country Risk Profiles

The CCRIF Tropical Cyclone Model
Historical events database

SPHERA: System for Probabilistic Hazard Evaluation and Risk Assessment – Data collected and sources

CCRIF SPC has created a database of **historical tropical cyclones** that occurred in the Caribbean and Central America from 1990 to 2017, and the **resulting economic losses**. A number of reports and databases were considered, such as those from NOAA[1], EM-DAT[2], Local sources (CDEMA[3], ECLAC[4], local newspapers, local websites, etc.) DFO[5], Wikipedia, Swiss Re, Munich Re, AON. Table 1 shows the information type available from each source.

Table 1. Information type available from each source

Source	Period	Fatalities & Overall Losses	Insured Losses	People Affected	Structures Affected
EM-DAT	1900 – present	X		X	
NOAA	1851 – present	X			
AON	2008 – 2017	X	X		X
MunichRe	1980 – 2017	X	X		
SwissRe	1990 – 2017	X	X		X
Wikipedia	Until 2017	X			
Local sources	Until 2017	X		X	

The information collected includes event start and end dates, maximum Saffir-Simpson scale category, economic losses, number of deaths, and number of people affected and displaced, when available. The distribution of the events among the different categories is presented in Figure 1.

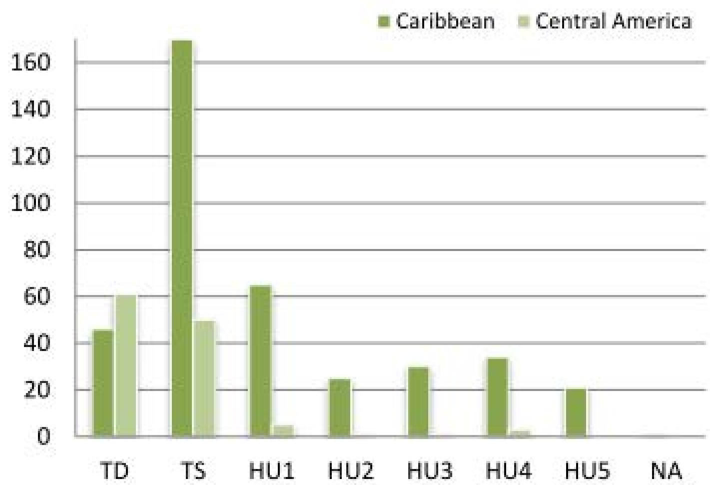


Figure 1. Number of events for each Saffir-Simpson scale category. The tropical cyclone severity scale includes TD (Tropical Depression), TS (Tropical Storm), and HU (Hurricane) categories from 1 to 5 in the Saffir-Simpson hurricane wind

Tropical Cyclone
Country Risk Profiles

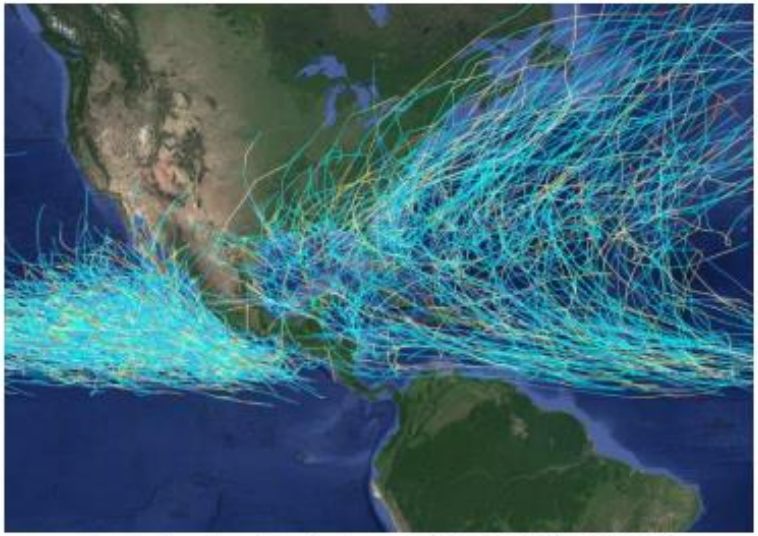
SPHERA TC – hazard section

Hazard

The hazard module of the SPHERA TC model provides a stochastic catalogue of potential future tropical cyclones that are statistically consistent with the historical tropical cyclone activity in the region. Records of cyclones in the region start in 1850; the map at right displays the tracks of events from 1998 to 2017. The catalogue is based on statistics of past events. From this catalogue it is possible to estimate the level of wind speed and storm surge expected in the region with different annual rates of exceedance.

The maps below show the maximum wind speeds (top) and the maximum sea level (bottom) generated by tropical cyclones that are expected to occur in the country with an average frequency of once every 50 and once every 250 years.

Average frequency of tropical cyclones

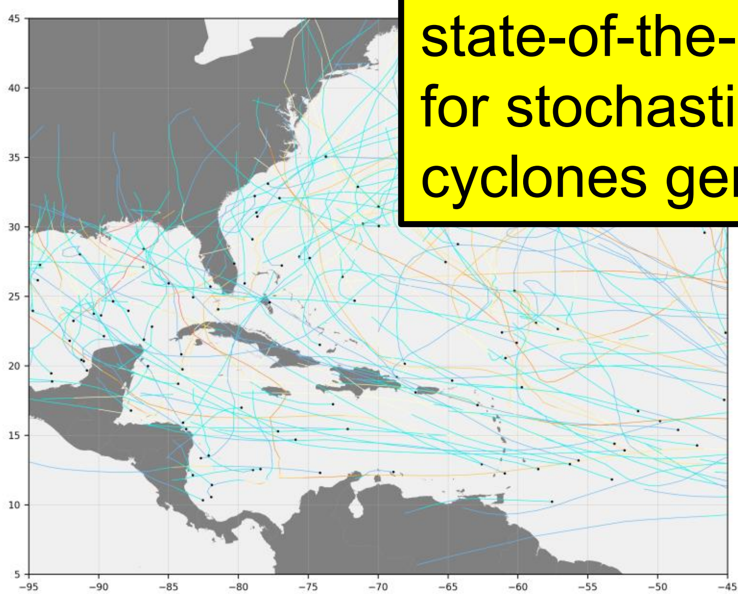


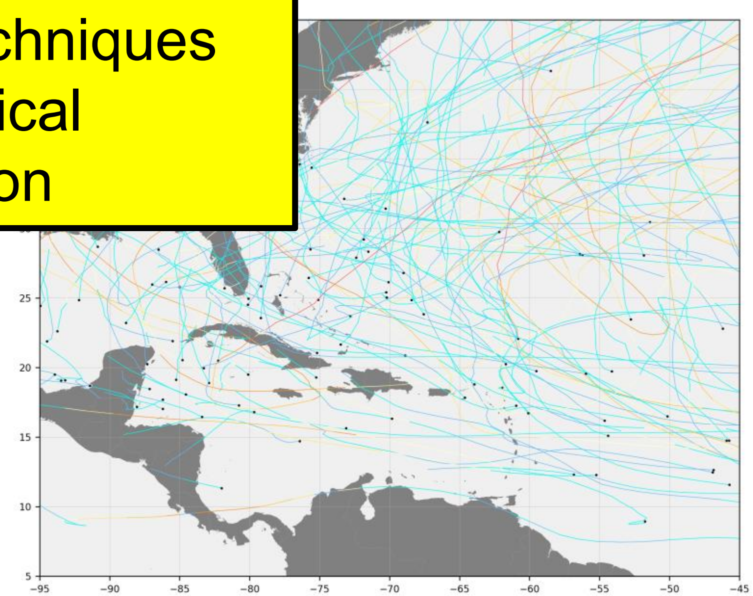
Tropical cyclone tracks from 1998 to 2017 (HURDAT2)

SPHERA TC – hazard section

- Stochastic catalogue: very large number of theoretical events
  - The statistical properties of the stochastic cyclones are the same (track, pressure, wind spe tc.)

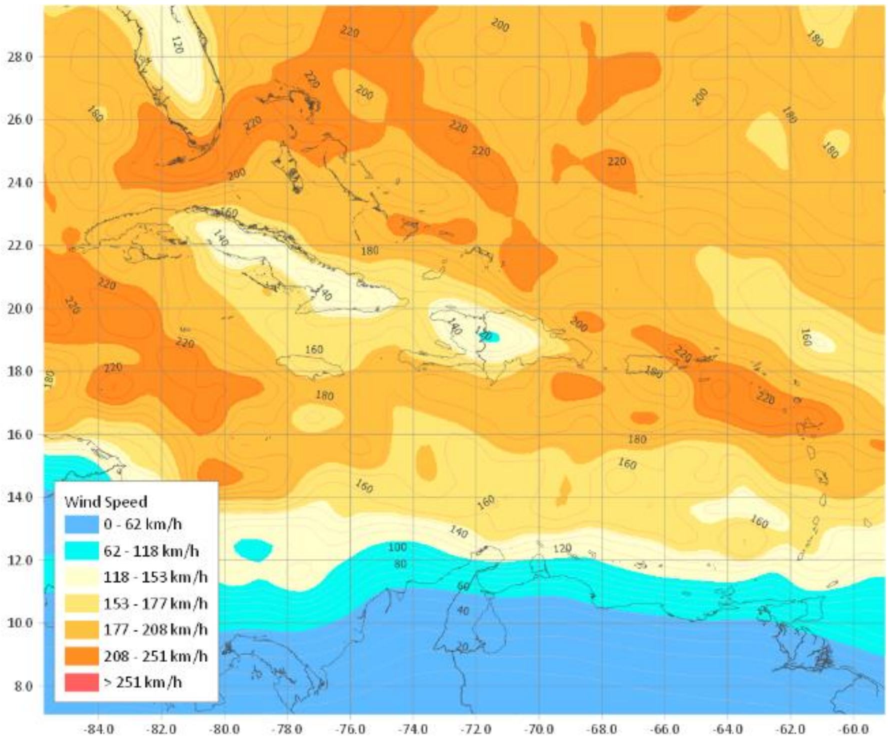
UPDATE 2023: A new stochastic catalog has been developed based on the state-of-the-art techniques for stochastic tropical cyclones generation



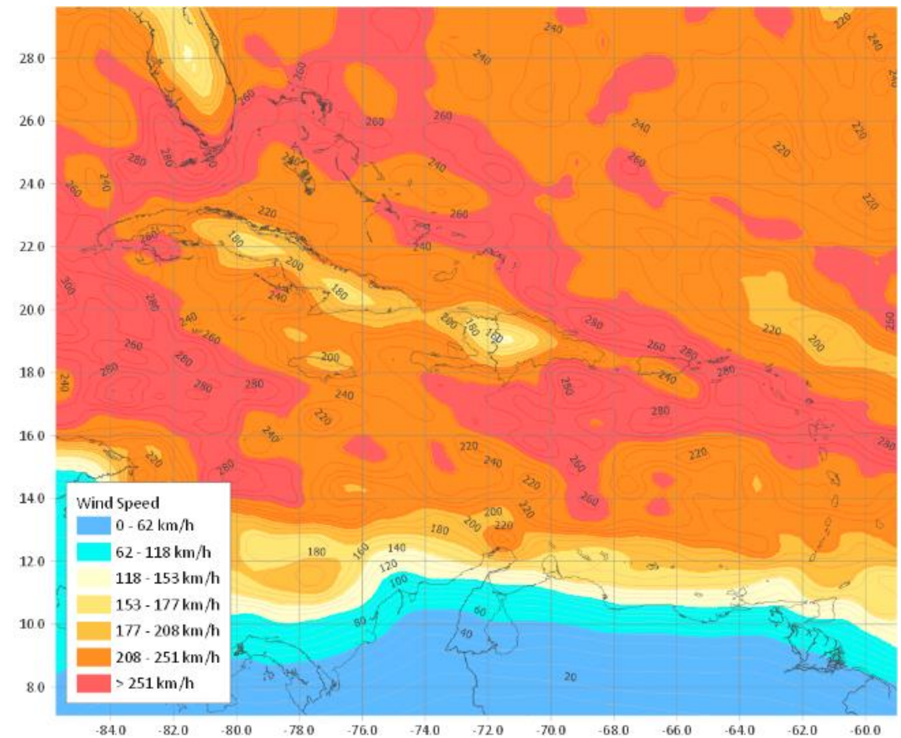


SPHERA TC – hazard section

TC Hazard for different return periods, using the stochastic events.



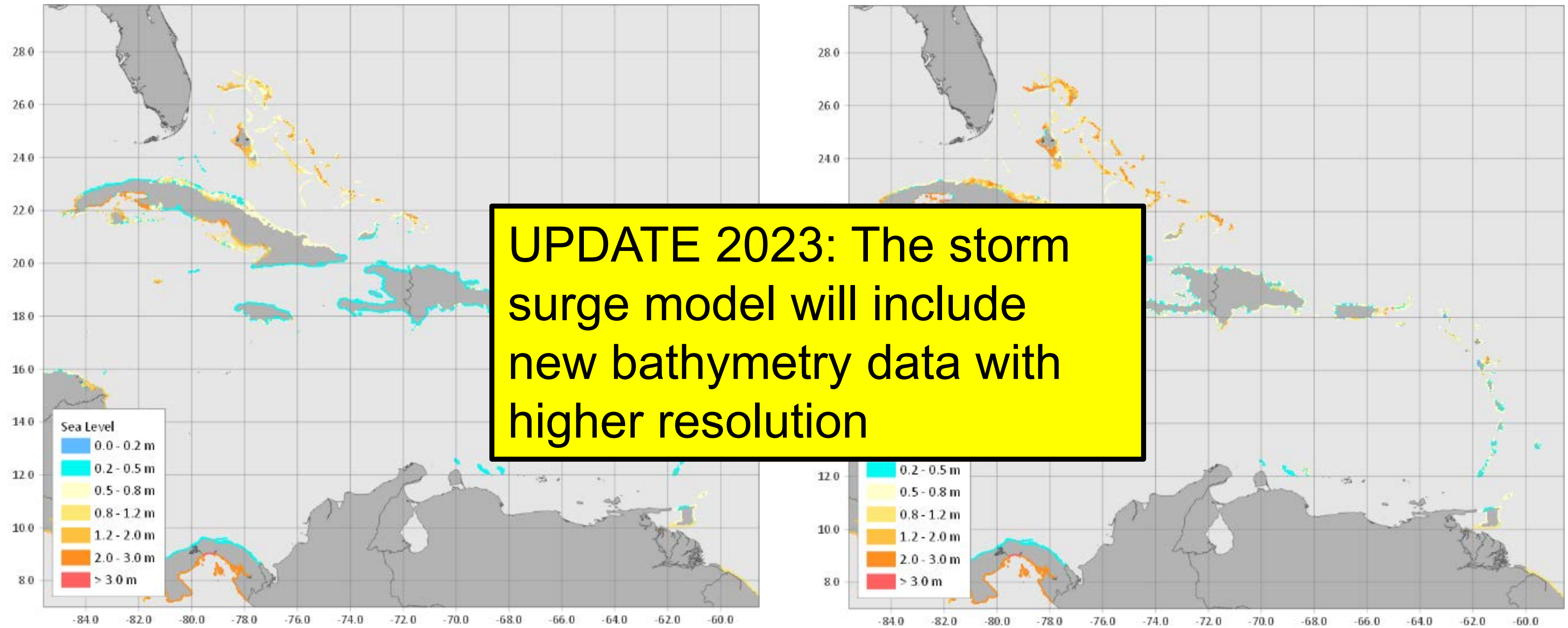
Wind speed for return period of 50 years



Wind speed for return period of 250 years

SPHERA TC – hazard section

TC Hazard for different return periods, using the stochastic events.



UPDATE 2023: The storm surge model will include new bathymetry data with higher resolution

SPHERA TC – exposure section

- The exposure database is built and validated on country level census data, technical documentation, international peer-reviewed literature, publicly available reports and databases, and satellite images.

SPHERA TC – exposure section

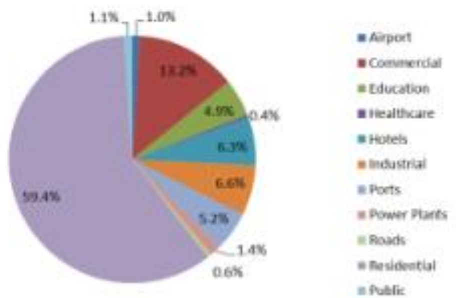
Exposure

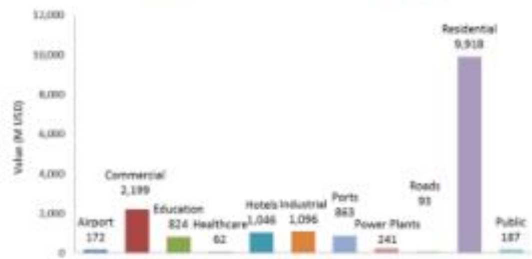
The exposure database provides count, replacement cost and vulnerability classification of different building classes and infrastructure assets. It has been developed by collating several sources of data up to 2017 related to the built environment and the surrounding topography. The resolution is of 1km^2 for inland areas and from approximately 250m^2 to 120m^2 for coastal areas.

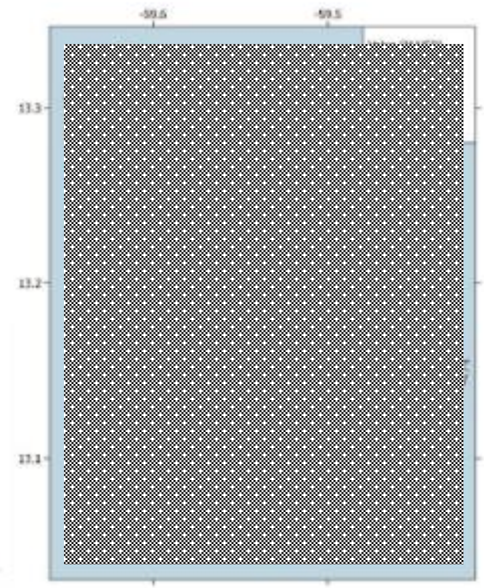
The map on the right shows the spatial distribution of the assets exposed to tropical cyclones. The representation is in terms of Replacement Value.

The two graphs show the breakdown of the replacement value of the assets at risk, classified by occupancy class, in terms of percentage (top) and absolute value (bottom).

Distribution of assets at risk







Crops Annual Production Value: 12.08 M USD

SPHERA TC – exposure section

- Used in:
  - Tropical cyclone risk model
  - Earthquake risk model
  - Excess of rainfall risk model
- Includes:
  - **Buildings** (re ial, education, healthcare,
  - **Infrastructu** ties, road network)
  - **Crops** (banana, maize, coffee, rice, sugar cane and generic)

UPDATE 2023: Currently damages to cash crops are considered only in TC, they will be included also in the XSR model

SPHERA TC – vulnerability section

Vulnerability

Consequences of high-intensity tropical cyclones

The vulnerability module estimates the possible consequences of a tropical cyclone on the different assets, described in the exposure database, that constitute the built environment. To do so the model makes use of relationships between the intensity of wind/surge and the repair cost of the exposed damaged assets.

Given the characteristics of the building stock of (more than 30% of the buildings are classified as wood buildings), the age of the building stock, the local building codes, the characteristics of the roofs and shutters and the preparedness of the country to tropical cyclones, the vulnerability of the country is classified as intermediate.

SPHERA TC – vulnerability section

Country	Code	Quality	Vulnerability Code
Country 1	ISO1	Good	VG1
Country 2	ISO2	Good	VG1
Country 3	ISO3	Good	VG1
Country 4	ISO4	Good	VG1
Country 5	ISO5	Good	VG1
Country 6	ISO6	Good	VG1
Country 7	ISO7	Good	VG1
Country 8	ISO8	Good	VG1
Country 9	ISO9	Good	VG1
Country 10	ISO10	Good	VG1
Country 11	ISO11	Good	VG1
Country 12	ISO12	Good	VG1
Country 13	ISO13	Good	VG1
Country 14			
Country 15			
Country 16			
Country 17			
Country 18			
Country 19			
Country 20			
Country 21			
Country 22			
Country 23			
Country 24			
Country 25			
Country 26			
Country 27			
Country 28			
Country 29			
Country 30	ISO30	Low	VG3
Country 31	ISO31	Low	VG3
Country 32	ISO32	Low	VG3
Country 33	ISO33	Low	VG3
Country 34	ISO34	Low	VG3
Country 35	ISO35	Poor	VG4

- Extensive research on the building stock at country level
- Four classes to consider the relative vulnerability level

UPDATE 2023: Vulnerability functions for TC will be updated based on calibration with the new stochastic catalog and the analysis of recent events (e.g., Elsa 2021)

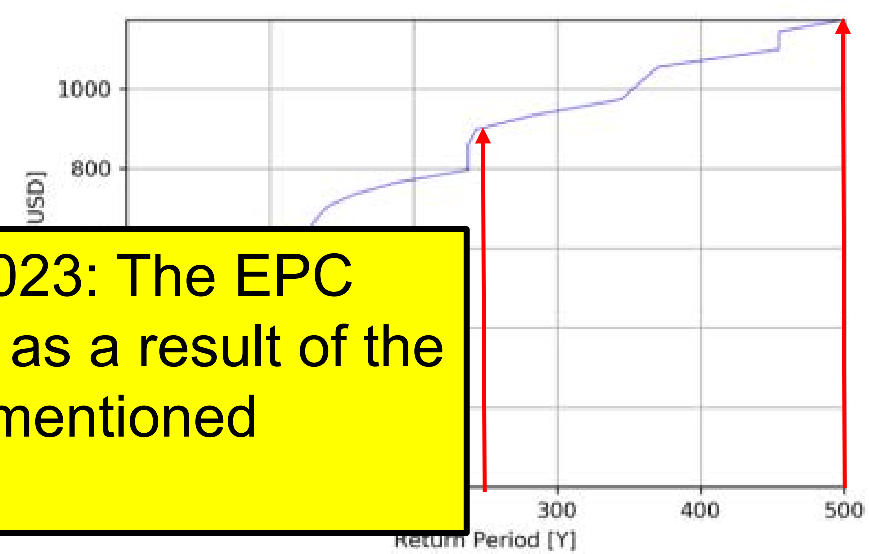
Code	Description
	High building stock quality
	Average building stock quality
	Low building stock quality
	Poor building stock quality

SPHERA TC – risk section

Risk

The estimate of TC risk in is based on the stochastic catalogue of potential future tropical cyclones that may affect the region and on the losses that they may cause to the exposed assets. The graph on the right shows the tropical cyclone-induced ground-up losses (OEP) that are expected to be exceeded, on average, once every certain numbers of years (the return period). The table below reports the numerical values of the losses associated with five return
the curve. It also shows the long-term
to tropical cyclone events.

Potential losses



Return Period (Years)	
20	
50	
100	608,000,000
250	904,000,000
500	1,173,000,000
Average Annual Loss	21,000,000

UPDATE 2023: The EPC will change as a result of the previously mentioned updates.

CRP_Page 4

SPHERA TC – historical losses section

From disaster databases (**EM-DAT**), international agencies (**ECLAC**), meteorological agencies (**NOAA**), local agencies (**CDEMA**), insurance/re-insurance companies (**MunichRe**, **SwissRe**, **AON**), …

Source	Period	Date & General information	People Affected	Fatalities	Structures Affected	Overall Losses	Insured Losses
EM-DAT	1900 – Present	✓	✓	✓		✓	
NOAA	1851 – Present	✓		✓		✓	
AON	2008 – 2017	✓		✓	✓	✓	✓
MunichRe	1980 – 2017	✓		✓		✓	✓
SwissRe	1990 – 2017	✓		✓	✓	✓	✓
Wikipedia	Until 2017	✓		✓		✓	
Local sources	Until 2017	✓	✓	✓		✓	

- Purpose: **model validation**

Annex 2

SPHERA TC – historical losses section

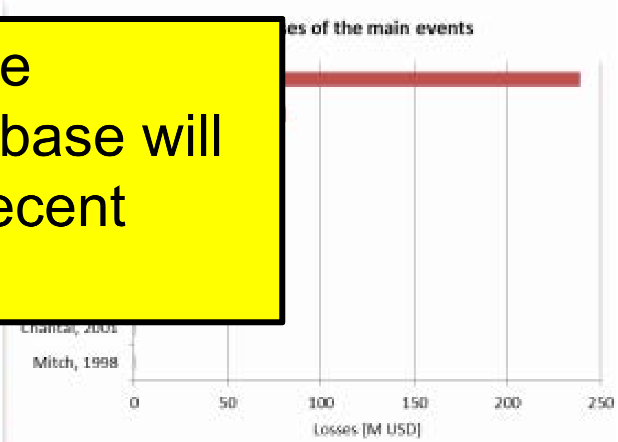
Historical Losses

Historical Economic Losses

During the period from 1990 to 2017, 27 Tropical Cyclones struck The table presents the 9 events with the highest reported consequences. The most destructive event was Tropical Cyclone Iris in 2001 which caused 27 fatalities. The overall reported losses in Belize for this event ranged between US$70 and US$370 million with a mean of approximately US$240 million.

Event	Start Date				
Earl, 2016	03/08				
Richard, 2010	24/10				
Sixteen, 2008	14/10				
Arthur, 2008	31/05				
Dean, 2007	20/08				
Iris, 2001	08/10				
Chantal, 2001	20/08	22/08	TS		0.42
Keith, 2000	01/10	04/10	TS	13	29.34
Mitch, 1998	27/10	04/11	TS	10	0.01

UPDATE 2023: The consequence database will include the most recent events



Category	Tropical Depression	Tropical Storm	Hurricane 1	Hurricane 2	Hurricane 3	Hurricane 4	Hurricane 5
Wind Speed (1 minute sustained winds)	≤ 38 mph	39–73 mph	74–95 mph	96–110 mph	111–129 mph	130–156 mph	≥ 157 mph
Central Pressure	> 980 mbar	> 980 mbar	> 980 mbar	965–979 mbar	945–964 mbar	920–944 mbar	< 920 mbar

SPHERA TC – new sections

ADDITIONAL TRIGGER FOR LOCALISED EVENTS

A trigger to activate the policy when **very extreme events affect a small area** of the country is being designed.

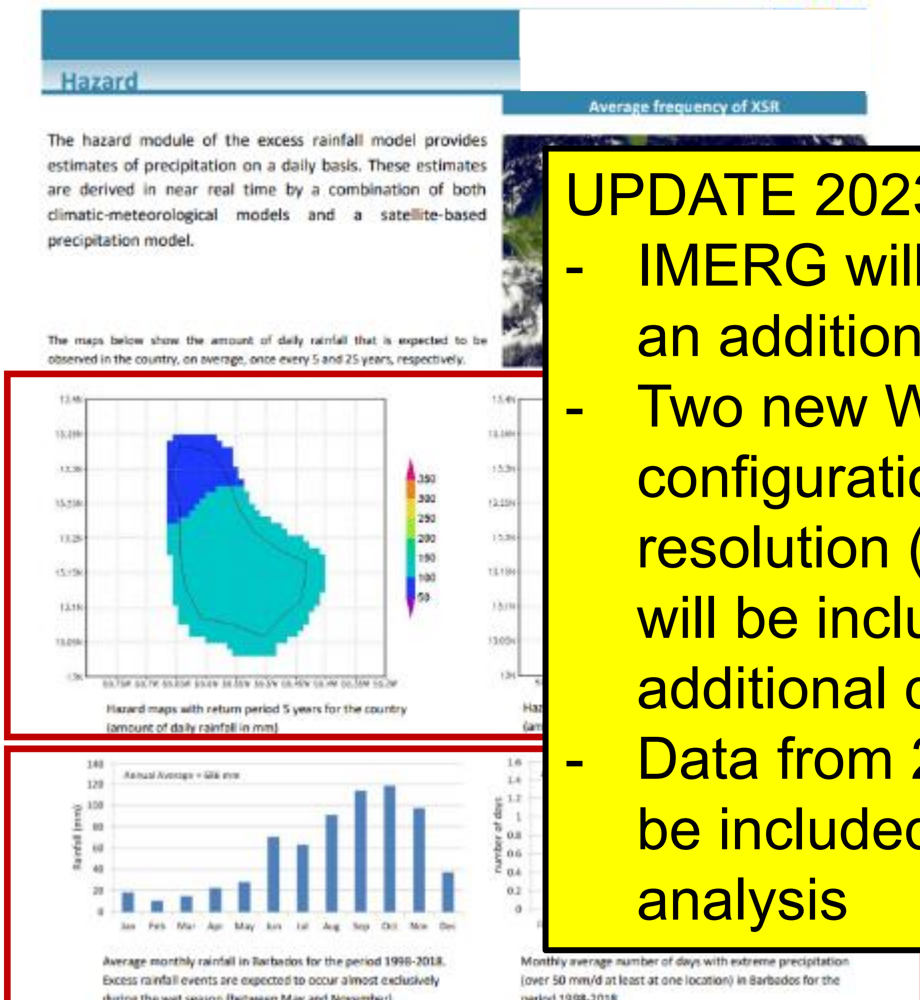
Objective is to cover remote areas or areas with low exposed values that when affected by an extreme event may not trigger the main policy or may trigger a small payout.

Examples: Dorian 2019 in Bahamas

Maria 2017 in Antigua and Barbuda

XSR
Country Risk Profiles

XSR 2.5 – hazard section



UPDATE 2023:

- IMERG will be included as an additional dataset
- Two new WRF configurations at high resolution (approx. 3.6 km) will be included as additional datasets
- Data from 2019 to 2022 will be included in the risk analysis

S

ellite data

vo return periods: 5

TISTICS

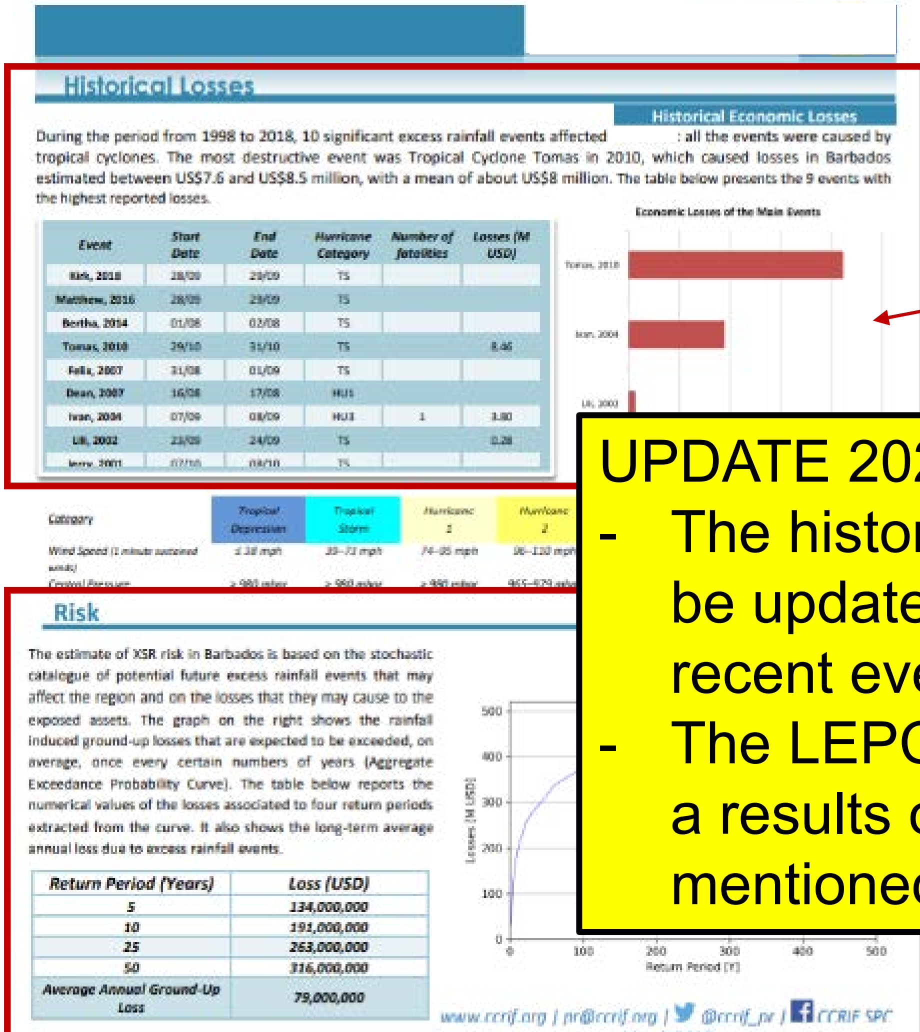
ellite data

rainfall seasonality

urrence of extreme

precipitation

XSR 2.5 – risk section



Historical Losses

Historical Economic Losses

During the period from 1998 to 2018, 10 significant excess rainfall events affected : all the events were caused by tropical cyclones. The most destructive event was Tropical Cyclone Tomas in 2010, which caused losses in Barbados estimated between US$7.6 and US$8.5 million, with a mean of about US$8 million. The table below presents the 9 events with the highest reported losses.

Event	Start Date	End Date	Hurricane Category	Number of fatalities	Losses (M USD)
Kirk, 2018	28/09	29/09	TS		
Matthew, 2016	28/09	29/09	TS		
Bertha, 2014	01/08	02/08	TS		
Tomas, 2010	29/10	31/10	TS		8.46
Felix, 2007	31/08	01/09	TS		
Dean, 2007	16/08	17/08	HU1		
Ivan, 2004	07/09	08/09	HU3	1	3.80
Lili, 2002	23/09	24/09	TS		0.28
Jerry, 2001	07/10	08/10	TS		

Category	Tropical Depression	Tropical Storm	Hurricane 1	Hurricane 2
Wind Speed (1 minute sustained winds)	≤ 38 mph	39–73 mph	74–95 mph	96–110 mph
Central Pressure	> 980 mbar	> 980 mbar	> 980 mbar	965–979 mbar

Risk

The estimate of XSR risk in Barbados is based on the stochastic catalogue of potential future excess rainfall events that may affect the region and on the losses that they may cause to the exposed assets. The graph on the right shows the rainfall induced ground-up losses that are expected to be exceeded, on average, once every certain numbers of years (Aggregate Exceedance Probability Curve). The table below reports the numerical values of the losses associated to four return periods extracted from the curve. It also shows the long-term average annual loss due to excess rainfall events.

Return Period (Years)	Loss (USD)
5	134,000,000
10	191,000,000
25	263,000,000
50	316,000,000
Average Annual Ground-Up Loss	79,000,000

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March 2019

HISTORICAL LOSSES

Derived from a variety of sources including some of the top providers of observed loss information such as Munich Re, Swiss Re, and Aon. In some cases, reported losses were adjusted for inflation and other economic factors (using the widely accepted Pielke scheme) and to account for the
…n of total loss for a multi-peril
…or peril being wind).

UPDATE 2023:

- The historical losses will be updated with the most recent events
- The LEPC will change as a results of the previously mentioned updates

…CE PROBABILITY CURVE

… losses simulated by the
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…olicy conditions

XSR 2.5 - new sections

ADDITIONAL TRIGGERS FOR LOCALISED EVENTS

A trigger to activate the policy when **very extreme events affect a small area** of the country is being designed.

Objective is to cover remote areas or areas with low exposed values that when affected by an extreme event may not trigger the main policy or may trigger a small payout.

Examples: Maria 2017 in Antigua and Barbuda

Diego Martin floods 2012 in Trinidad

XSR 2.5: Other updates

ADDITIONAL TRIGGERS FOR WET SEASONS

A trigger to activate the policy when **non-extreme events affect** the country during an **extremely wet season** is being designed.

Objective is to cover damages caused by rainfall events that are not extreme in terms of precipitation intensity, but that may cause severe damages because they happen during an extremely wet season.

Example: October 2020 in Jamaica

Earthquake
Country Risk Profiles

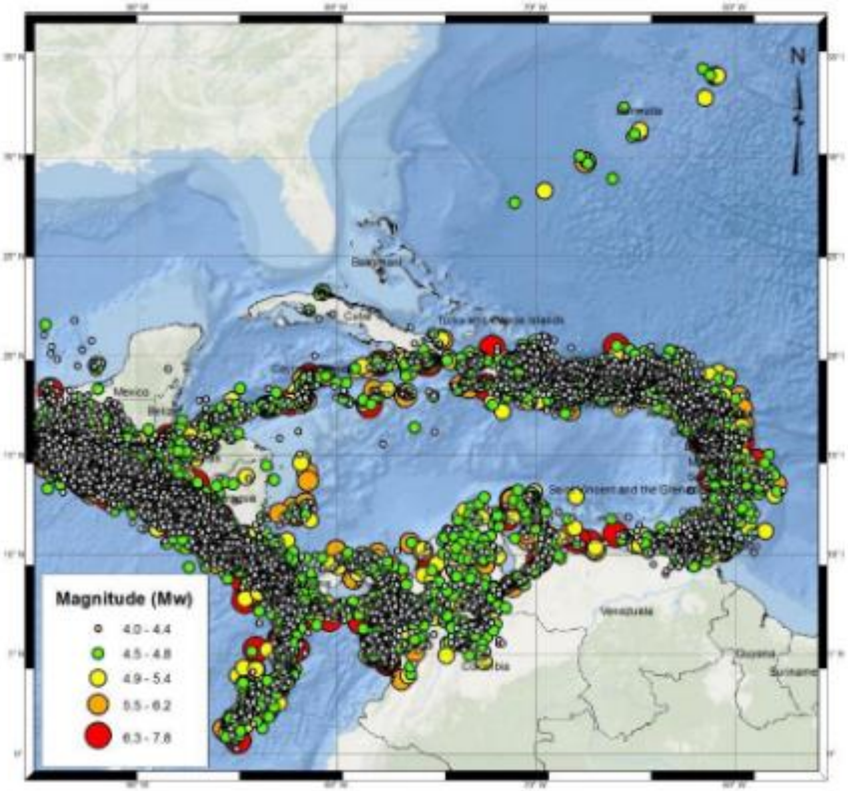
SPHERA EQ – hazard section

Hazard

The hazard module of the SPHERA EQ model provides a stochastic catalogue of potential future earthquakes that are statistically consistent with the historical seismicity in the region, displayed in the map at right. This catalogue is based on statistics of past events and on the knowledge about location, geometry and rate of activity of the earthquake sources (faults) present in the area of interest. From this catalogue it is possible to estimate the level of earthquake ground motion expected in the region with different annual rates of exceedance.

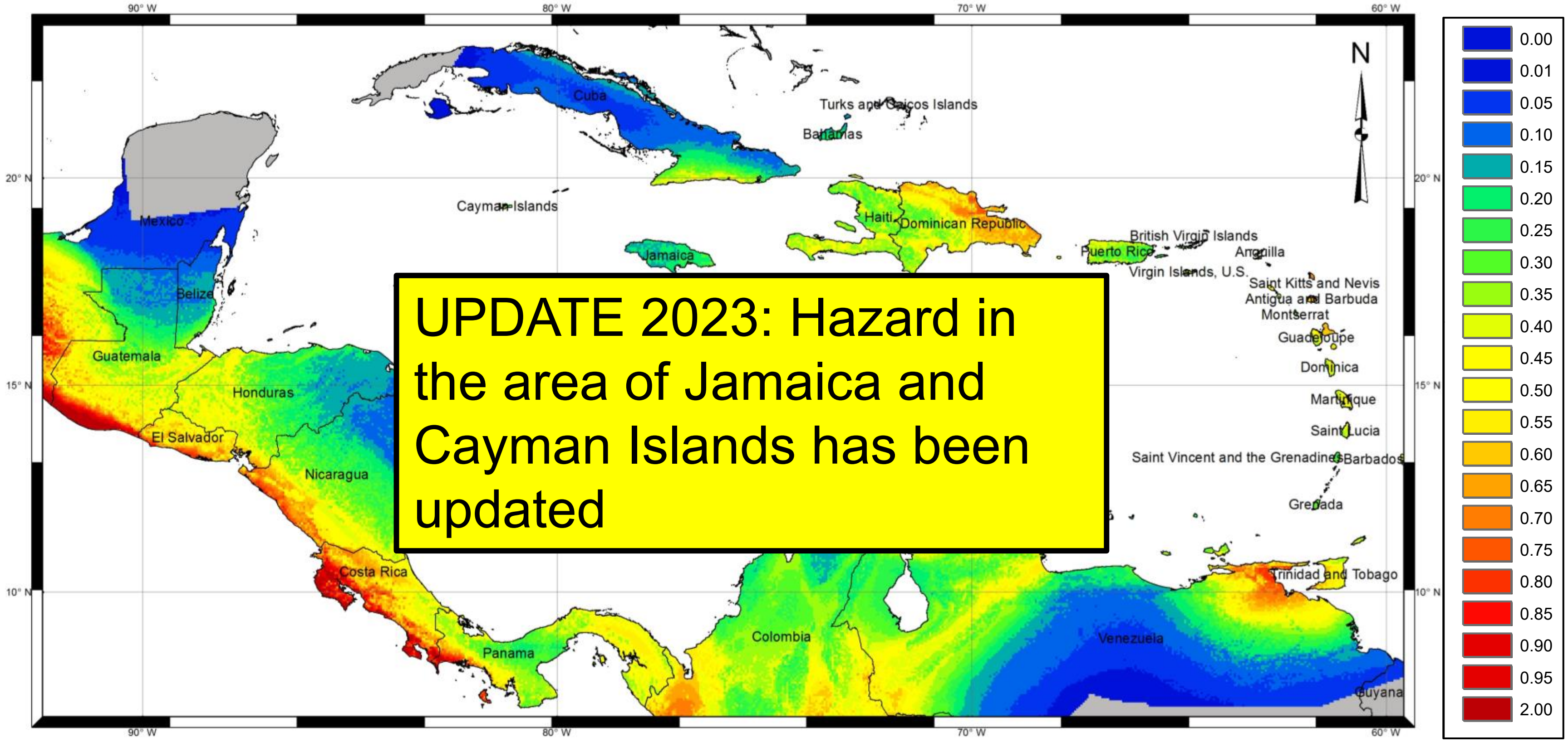
The maps below show the Peak Ground Acceleration expected to occur in the country with an average frequency of once every 95 (left) and once every 475 years (right).

Average frequency of earthquakes



SPHERA EQ – hazard section

➢ The peak ground acceleration on rock (PGA, in g) expected to be exceeded on average once every 475 years for the region. Maps taken from the CRP



UPDATE 2023: Hazard in the area of Jamaica and Cayman Islands has been updated

CRP_Page 2

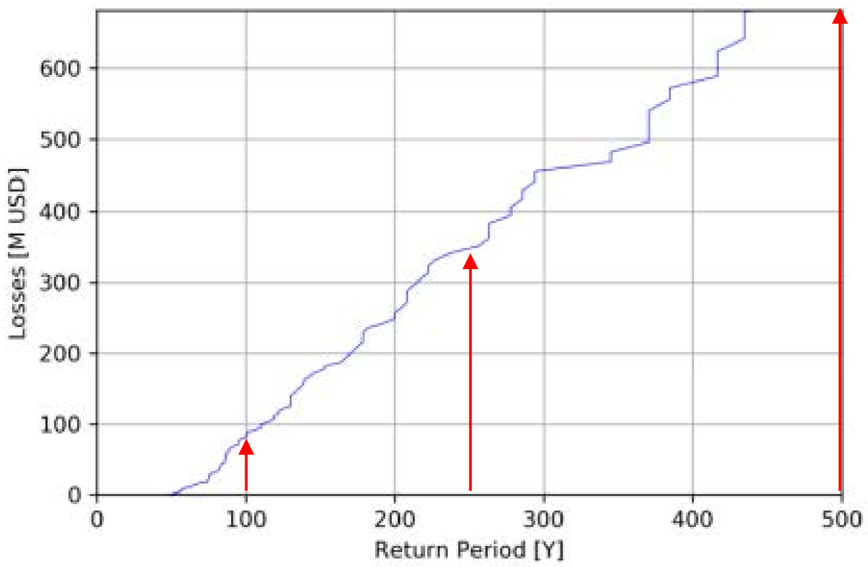
SPHERA EQ – risk section

Risk

The estimate of EQ risk in Barbados is based on the stochastic catalogue of potential future earthquakes that may affect the region and on the losses that they may cause to the exposed assets. The graph on the right shows the earthquake-induced ground-up (OEP) losses that are expected to be exceeded, on average, once every certain numbers of years (the return period). The table below reports the numerical values of the losses associated with four return periods extracted from the curve. It also shows the long-term average annual loss due to earthquake events.

Return Period (Years)	*Loss (USD)*
50	*900,000*
100	*82,000,000*
250	*349,000,000*
500	*682,000,000*
Average Annual Loss	*4,600,000*

Potential losses



Conclusions and Next Steps

Conclusions and next steps

CCRIF's risk profiles are designed specifically to be used as a **complementary tool for its parametric insurance policies**

The risk assessment included in the risk profile is used to **design the country insurance policies**

The risk assessment included in the risk profile is **consistent with the real time model** (the same model is used behind both applications)

Conclusions and next steps

The main objective of CCRIF's country risk profiles is to provide a clear picture of the key risks that the country faces in order to guide national catastrophe risk management and inform decision making for both risk reduction and risk transfer.

Once the CRPs have been reviewed by the country, making these documents publicly available, for instance on the CCRIF website, can benefit several DRM practitioners at the local and international level

Other Uses for the Country Risk Profiles

Besides the use of the Country Risk Profiles for which these were developed, valuable information can be found in the profiles for:

- Reinsurers
- Local disaster risk managers
- Decision-makers for land use, investment and development planning
- Local and international disaster risk managers

Making the Country Risk Profiles available would allow raising risk awareness

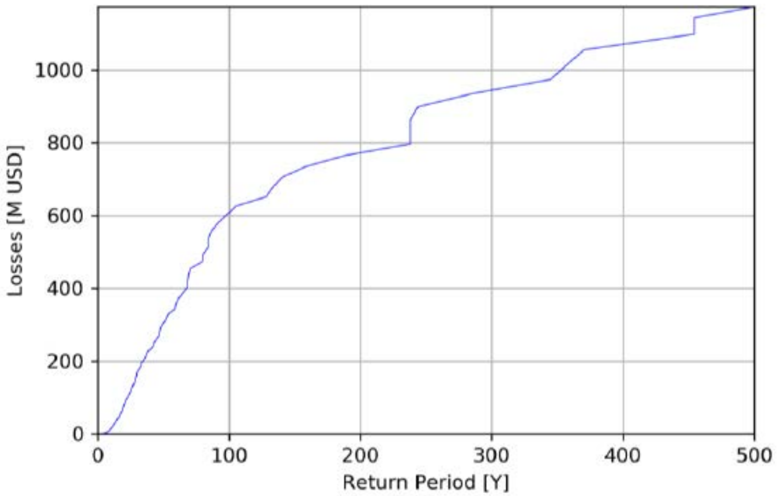
Financial protection is only one component of a comprehensive disaster risk management scheme. Country Risk Profiles present information that give a complete overview of the potential losses for each country.

Using the Country Risk Profiles

Reinsurers

- Country Risk Profiles summarize the catastrophe risk overview of the country in commonly used metrics in the industry
- OEP curves, AAL, losses for given return periods are included
- The documentation of the approach followed for all the components of CCRIF's models facilitate the understanding of data used, assumptions, verifications and validations

Return Period (Years)	*Loss (USD)*
20	*82,000,000*
50	*304,000,000*
100	*608,000,000*
250	*904,000,000*
500	*1,173,000,000*
Average Annual Loss	*21,000,000*



Using the Country Risk Profiles

Local disaster risk managers

- Updated maps for cyclonic wind, storm surge, earthquake and excess rainfall hazards are included in the Country Risk Profiles
- Information from these maps can be used to identify first-order hazard prone locations, highlighting which locations may require a more detailed and local analysis
- The data contained in the risk profiles can also be used in the preparation of national disaster management plans
- Hazard information included in the Country Risk Profiles can be used to review and update, when needed, local building codes

Using the Country Risk Profiles

Land-use and development planners

- Hazard maps in the Country Risk Profiles allow a first-order identification of hazard prone areas
- Risk results are currently aggregated at country level and potential losses summarized into a single value. However, the model allows disaggregating risk data, for example, into:
    - Sub-national areas
    - Lines of Business (sectors)
- Risk maps and charts with the disaggregation of the potential losses can be generated
- Risk concentrations in particular lines of business or districts could be for instance identified

Using the Country Risk Profiles

Financial and investment planners

- CRPs for CCRIF are fit for purpose and have gone through a comprehensive validation and peer-review process
- Financial protection is only one of the components of a comprehensive DRM strategy
- Country Risk Profiles provide information that can be used to draft policies for risk identification, prevention and mitigation
- Country Risk Profiles provide an estimate of the value at risk from a governmental perspective

Using the Country Risk Profiles

National and international DRM community

- Country Risk Profiles provide valuable information to raise risk awareness at local and international level
- CRP's show that risk assessments have been made for the country avoiding duplication of efforts
- CCRIF's Country Risk Profiles reflect the results of much more detailed and comprehensive risk assessments than others publicly available (e.g., GAR15)