# The CCRIF Excess Rainfall (XSR) Model

## The CCRIF Excess Rainfall (XSR) Model and XSR Product

Caribbean and Central American countries are often exposed to the severe consequences of natural hazards. Besides wind and ground shaking, which are the primary effects of these events, secondary effects such as flooding, landslides, storm surge and wave impacts, and tsunamis also pose significant threats. Additionally, these countries are frequently affected by extreme precipitation events that are often, but not always, induced by tropical cyclones. The consequent losses are mostly caused by the accumulation of water over the land and, in the case of steep topography, by the high velocity of the water overflowing the land. These effects are further exacerbated by degraded ecosystems such as watersheds and forests.

Also, the vulnerabilities of these countries to weather-related natural hazards will likely worsen due to climate change. Climate change is expected to result in more frequent high-intensity hurricanes, accelerate the erosion of coastal beaches, cause inundation of low-lying land and to progressive loss of the protective coastal mangrove forests. Climate change also is expected to increase rainfall variability. Greater and, therefore, more damaging precipitation during storms will alternate with more frequent, severe and longer periods of drought.

From as far back as 2010, Caribbean governments expressed strong interest in CCRIF developing and making available an excess rainfall insurance product to complement the existing hurricane and earthquake products and as a means of reducing their rainfall risk. In 2013, CCRIF launched an excess rainfall parametric insurance product and currently 12 member governments have purchased XSR coverage. Since the introduction of the product, CCRIF has made five payouts totaling US$5.8 million to four of these member countries on their XSR policies.

CCRIF has recently enhanced the existing rainfall model to improve the accuracy of the near-real-time rainfall estimates and to simplify the structure of the excess rainfall policy. The new model is called the CCRIF Excess Rainfall (XSR) 2.0 Model. The XSR 2.0 Model is aimed at simulating in near real time the precipitation over a country and at rapidly estimating the potential consequent losses to public assets such that shortly after the end of the XSR event the country can receive a payout consistent with the CCRIF insurance policy conditions when the country's rainfall policy is triggered.

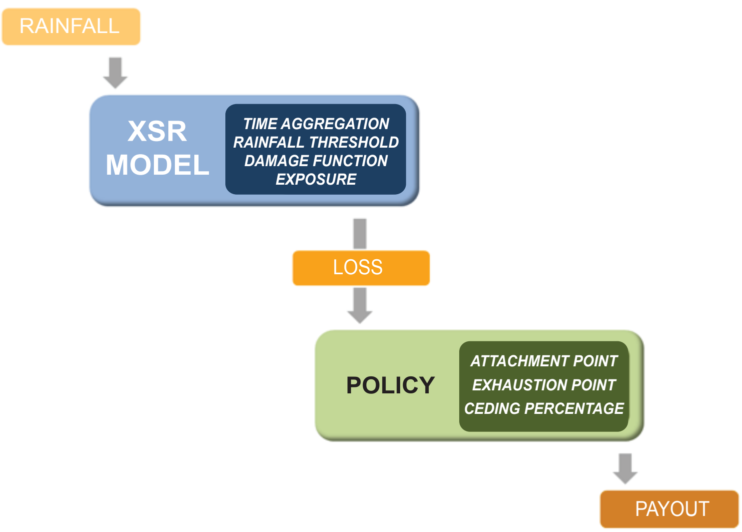
Unlike traditional parametric insurance products that are based only on event parameters, the CCRIF XSR model estimates rainfall-induced losses to the built environment. The XSR model is a flexible tool that provides options for managing the identified XSR risk according to the financial needs of each country.

## Components of the CCRIF XSR Model 2.0

The XSR Model is made up of the following modules:

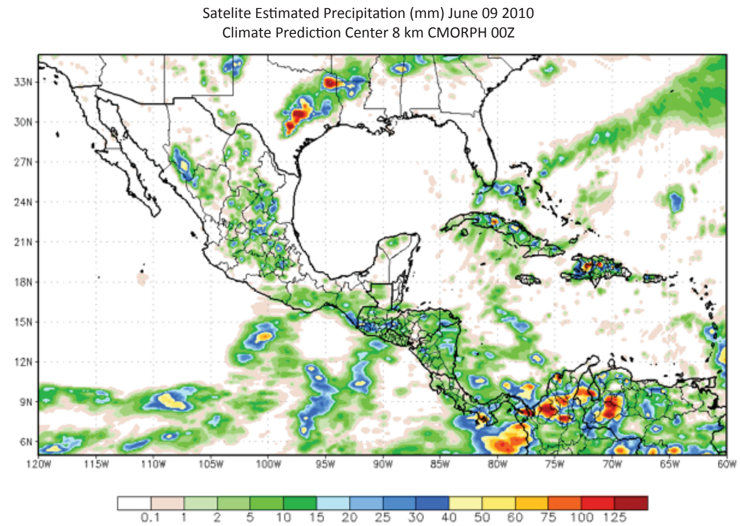
- **Exposure Module,** which describes the built environment assets in each country
- **Hazard Module**, which estimates the aggregated amount of rainfall over a country during the temporal length of the storm
- **Vulnerability Module**, which establishes relationships between aggregated rainfall and losses (i.e., the so-called vulnerability functions)
- **Loss Module**, which computes the modelled losses due to the XSR event
- **Insurance Module**, which – based on the policy conditions, specifically the country-specific attachment point, exhaustion point and ceding percentage – determines if a country's policy is triggered and, if so, computes the payout to the country

The conceptual flow of the XSR Model is shown in the figure below. The XSR model captures a rainfall event when the estimated rainfall threshold aggregated over a period of time (e.g., 2 days) during the length of the storm is exceeded, affecting a sufficiently large portion of the country's assets.




## The HAZARD Module: How frequent are XSR events?

The hazard module provides on a daily basis estimates of the precipitation over a large domain that includes the Caribbean and Central America regions. The daily estimates are derived in near real time through a combination of climatic-meteorological models (the WRF[1] Model initialized by the NCEP-FNL[2] model developed by the United States National and Oceanic and Atmospheric Administration-NOAA), which compute the amount of rainfall based on climate conditions, and of a low-orbiter satellite-based precipitation model (CMORPH[3]) developed by the NOAA Climate Prediction Center. The WRF models, which are weather forecast models, reproduce accurately the intensity of the rainfall event, while CMORPH, which is based on satellite data, captures precisely, both spatially and temporally, the location of the rainfall caused by the event. Therefore, to take advantage of the strengths of both approaches the rainfall estimates based on both the forecast model simulations and on the satellite data are utilized. An example of daily rainfall estimates for June 9, 2010 estimated by NOAA using CMORPH is shown in the figure below.




An XSR event is determined by the amount of average rainfall over a sufficiently large portion of the exposure that falls during an accumulation period of 2 days in Caribbean countries and of 4 days in Central American countries. The number of accumulation days and the value of the average rainfall amount are country-specific and are optimized to increase the likelihood that severe XSR events are captured by the model and moderate events are not falsely detected.

Although this procedure yields global precipitation estimates at low resolution, they are downscaled to a high resolution of **1 km$^2$** over the entire domain prior to their use as input to the loss computations for XSR events. The downscaling brings the precipitation at a level of granularity consistent with that of the exposure database of the XSR Model.

[1] *Weather Research and Forecasting*
[2] *National Center for Environmental Prediction*
[3] *Climate Prediction Center Morphing Technique*

## Methodology

### Spatial domain

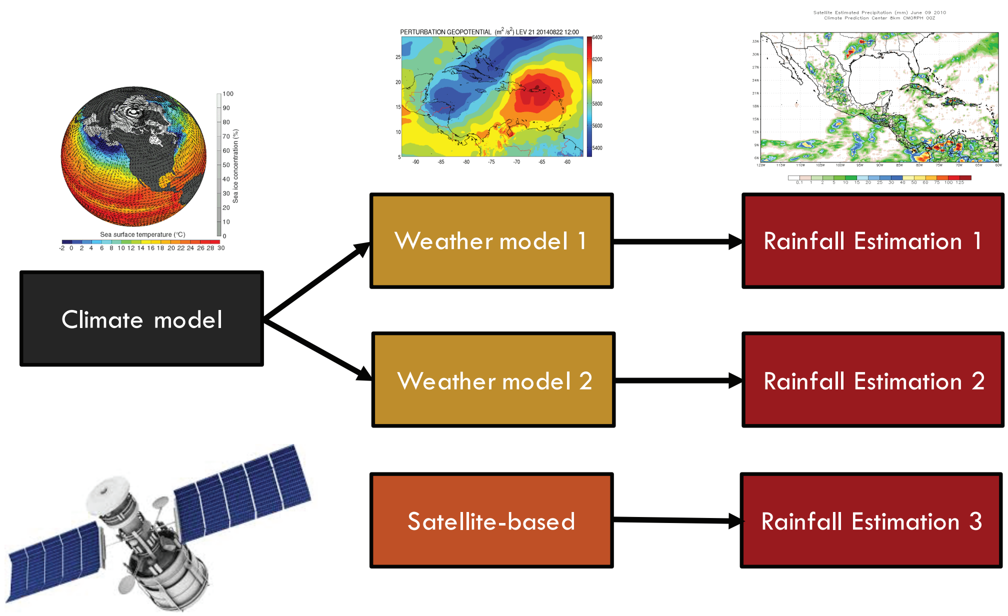
The spatial domain of the model comprises all the Caribbean and the Central America countries.
The geographic boundaries are:

| | |
|---|---|
| North | 36.0° |
| South | 0.0° |
| East | -49.0° |
| West | -98.0° |

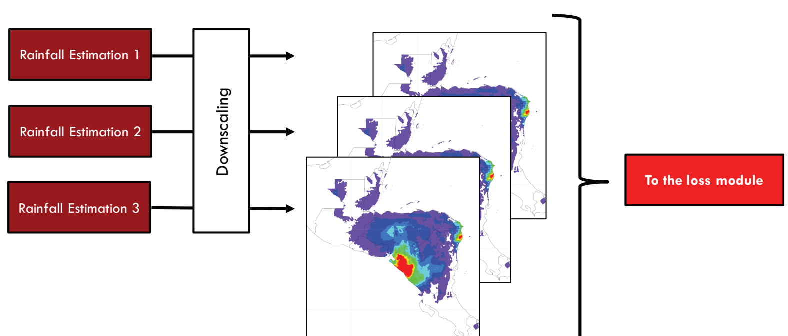

### Model framework

The hazard module of the XSR 2.0 Model uses a probabilistic approach to reduce the inevitable inaccuracies associated with the rainfall estimates of the satellite-based and weather forecast-based models. The hazard model produces three sets of rainfall estimates: two from different parameter configurations of the WRF model and one from CMORPH.

More precisely, the climate model (NCEP FNL, see next paragraph for the details) initializes the weather forecast model (WRF, see next paragraph for the details) which is run with two different configurations for the cumulus parameterization (1. Kain-Fritsch, 2. Betts-Miller-Janjic – see http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3/users_guide_chap5.htm#_Description_of_Namelist). The two WRF configurations produce rainfall estimates #1 and #2 on a daily basis at a grid resolution of 8 km. Independently, the CMORPH (see next paragraph for details) produces precipitation estimates derived from satellite observations These precipitation estimates are available on a grid with a spacing of 8 km. This dataset is rainfall estimate #3.




The three rainfall estimates are downscaled to a grid resolution of 1 km by means of an interpolation approach, based on the revised Akima's method. The method is based on a piecewise function composed of a set of polynomials, each of degree three, at most, and applicable to successive intervals of the given points. In this method, the slope of the curve is determined at each given point locally, and each polynomial representing a portion of the curve between a pair of given points is determined by the coordinates of and the slopes at the points.




The downscaled rainfall estimates are then passed to the loss module for the computation of the rainfall index loss.

## The dataset and models used

### The initialization dataset: NCEP FNL

The NCEP FNL (Final) Operational Global Analysis data are available (see http://rda.ucar.edu/datasets/ds083.2/) on 1-degree by 1-degree grid prepared operationally every six hours. This product is from the Global Data Assimilation System (GDAS), which continuously collects observational data from the Global Telecommunications System (GTS), and other sources. The FNLs are made with the same model used by NCEP in the Global Forecast System (GFS), but the FNLs are prepared about an hour or so after the GFS is initialized. The FNLs are delayed so that more observational data can be used. The GFS is run earlier in support of time-critical forecast needs, and uses the FNL from the previous 6-hour cycle as part of its initialization. The analyses are available on the surface, at 26 mandatory (and other pressure) levels from 1000 millibars to 10 millibars, in the surface boundary layer and at some sigma layers, the tropopause and a few others. Parameters include surface pressure, sea level pressure, geopotential height, temperature, sea surface temperature, soil values, ice cover, relative humidity, u- and v- winds, vertical motion, vorticity and ozone.

| | |
|---|---|
| Spatial resolution | 1° (about 100 km) |
| Temporal resolution | 6 hours |
| Time availability | -12 h |
| Inception year | 1998 |
| Precipitation estimation | NO |

### The weather forecast model: WRF model

The Weather Research and Forecasting (WRF) Model (http://wrf-model.org) is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting needs. It features two dynamical cores, a data assimilation system, and a software architecture facilitating parallel computation and system extensibility. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. The effort to develop WRF began in the latter part of the 1990s and was a collaborative partnership principally among the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (represented by the National Centers for Environmental Prediction (NCEP) and the then Forecast Systems Laboratory (FSL)), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA).

| Main parameters |
|---|
| ARW version |
| 641x481 horizontal points |
| 30 vertical levels |
| Standard configuration |
| Different convection schemes |

| | |
|---|---|
| Spatial resolution | 0.77° (about 8 km) |
| Temporal resolution | 3 hours |

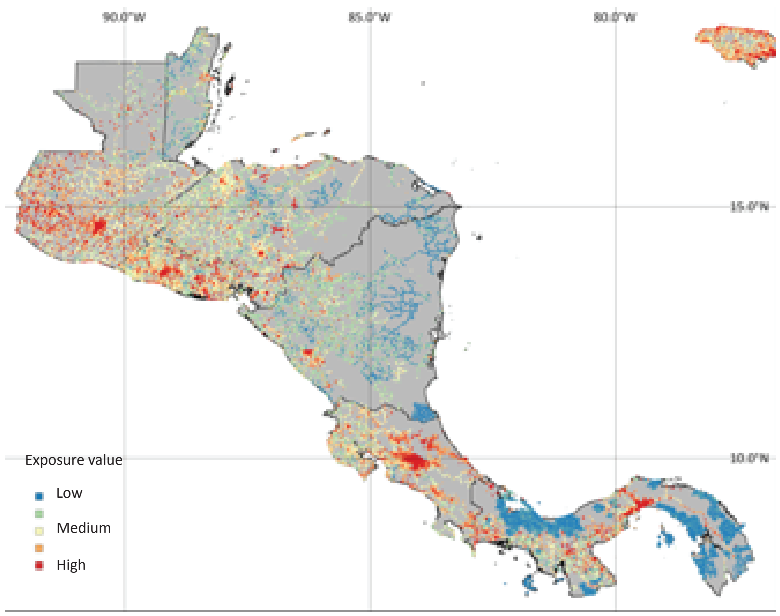
### The satellite based precipitation dataset: CMORPH

CMORPH (CPC MORPHing technique), whose detailed description can be found at: http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html), produces global precipitation analyses at a very high spatial (8 km) and temporal (30 min) resolution. This technique uses precipitation estimates derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data" (source: RDA abstract on CMORPH). The rainfall data produced by CMORPH is available at ftp://ftp.cpc.ncep.noaa.gov/precip/global_CMORPH/30min_8km/.

| | |
|---|---|
| Spatial resolution | 0.077° (about 8 km) |
| Temporal resolution | 30 min |
| Time availability | +18 h |
| Since year | 1998 |
| Precipitation estimation | YES |

## The EXPOSURE Module: Which assets and values are at risk?

The exposure dataset utilizes several **sources of data** related to the built environment and to the surrounding topography. These datasets include national building census surveys, land use/land cover maps, nighttime lights, population censuses, Digital Elevation Maps (DEMs), and satellite imagery among others. The final exposure database comprises information about the number of different types of structures, their area and their economic value. The exposure assets are grouped by structure classes of similar vulnerability to flooding. The database provides estimates of the ***asset count and replacement cost*** **by structure class at a 30 arc second resolution (approximately 1x1 km$^2$)**. The figure below shows photos of buildings that can be found in the region and, as an illustrative example, the density of replacement cost of buildings in the six Central America countries available in the derived database.





## Methodology and datasets used

The XSR 2.0 exposure module comprises a number of structures, including their geo-locations and economic values, in each the following sectors:

- Residential buildings
- Commercial buildings
- Industrial facilities
- Hotels and restaurants
- Healthcare infrastructure
- Education infrastructure
- Airports and ports
- Transportation (road) network

The module makes up a so-called 'Industry Exposure Database' or IED that is meant to represent valued assets (both private and public) across the Caribbean and Central America regions. The IED used in the XSR model is a gridded 1km x 1km database. The process by which the IED is developed involves a number of steps many of which leverage GIS tools and datasets. First, construction types are identified in each country. Next, a building count is estimated and economic values are assigned, again by country. Last, the distribution of exposure is estimated using independent data sources such as population. This process results in a gridded representation of the exposure distributed across each participating country.

## Night-time lights

A common dataset to distribute buildings within a given region is the night-time lights layer (i.e., data regarding the light intensity during the night on a 30 arc second resolution grid). This dataset is particularly useful to spatially distribute the commercial and industrial building stock, as there is a strong correlation between electrification and industrialization.

## Land use

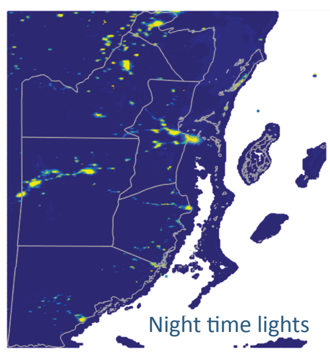
These datasets usually classify the territory of each country according to its use. Common categories are residential, industrial, commercial, farmland (agriculture), infrastructure and government/public facilities. Land use datasets are usually produced at a local level for urban planning purposes, at a regional level by request from a local government, or at a national level by open-access initiatives such as OpenStreetMap.

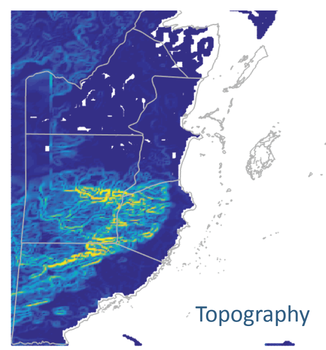
## Digital Elevation Map (DEM)

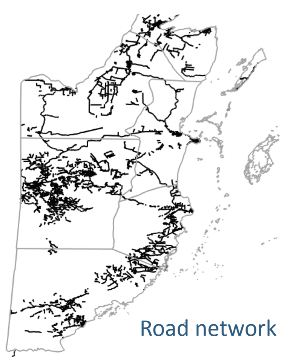
The topography of a certain region has been used in the development of exposure information and risk models in three ways. Firstly, the elevation (usually relative to the closest waterline) can be an important parameter in the assessment of losses due to floods or storms. Secondly, the slope of the terrain might be used as a proxy for human activity, as urban settlements tend to exist in flat areas (e.g. valleys) as opposed to regions with steep slopes. Thirdly, the slope of the terrain can be used as a proxy for the consistency of the surficial soil, which is important for assessing its potential to amplify seismic waves.

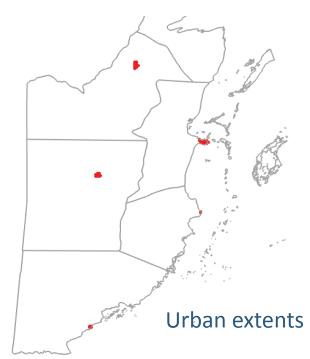
## Roads

Datasets at the national level containing the transportation network for each country were collected. These datasets contain the spatial distribution of railways and roads, with the latter component usually sub-divided into primary, secondary and tertiary roads. With the exception of the first type of roads (which are usually used to connect large urban centres) there is a strong correlation between the density of these roads and the presence of buildings. Several sources for this type of information can be found, from private companies (usually responsible for updating GPS maps) to publicly open initiatives such as Bing, Google, Digital Chart of the World, and OpenStreetMap.



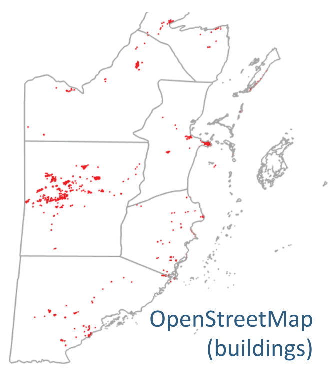



## Satellite imagery

The remote sensing data played a fundamental role in the urban density mapping. The images used here have been acquired by the optical 'Landsat-8' satellite. These are composed of: 8 multispectral bands at 30m spatial resolution, 1 panchromatic band at 15m spatial resolution, and 2 further thermal bands at 100m spatial resolution (resampled at 30 m).

The method used to map urban density can be divided into three phases. The first one consisted of collection of cloud-free data for the entire region of interest. In the second phase, the collected remotely sensed data were used to conduct the urban density mapping procedure. Finally, in the third and last phase, manual refining was performed over the entire region of interest.


## OpenStreetMap data

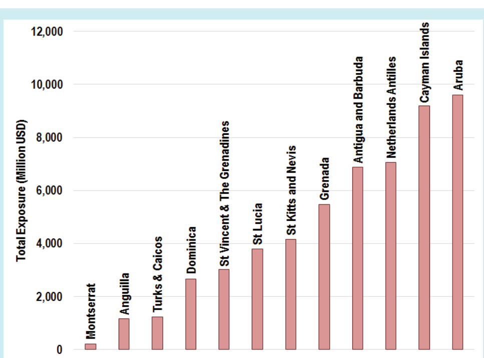
OpenStreetMap (OSM) is a collaborative project begun in 2004 at University College London, with the aim of creating a free geographic database of the entire world. Because many sources of geographic data are provided with licenses restricting their use, OSM's data are distributed under the "Creative Commons Attribute-ShareAlike 2.0 license", which allows freedom of use by the public. OSM is probably the most popular and successful Volunteered Geographic Information initiative, as supported by recent investigations on its completeness and quality. OSM is well ahead of mapping only the street network, as it contains a plethora of spatial data such as roads, buildings, land use areas and points of interest, emphasizing the potential of its use in the development of exposure models globally.

## Rivers and inland water

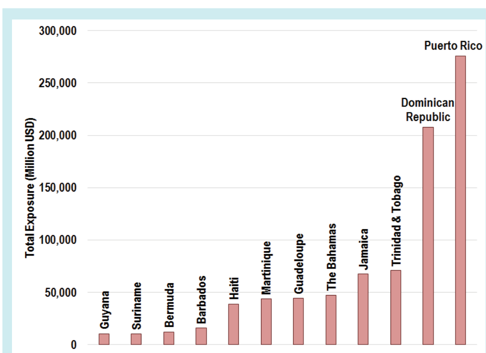
The procedure to spatially distribute the exposed assets also considered the areas where no buildings exist due to the presence of rivers or other inland water bodies (lakes, lagoons, etc.). This information is usually provided as part of a country administrative boundaries, or through the Digital Chart of the World. The latter source was utilized for this effort.

## Total exposure values

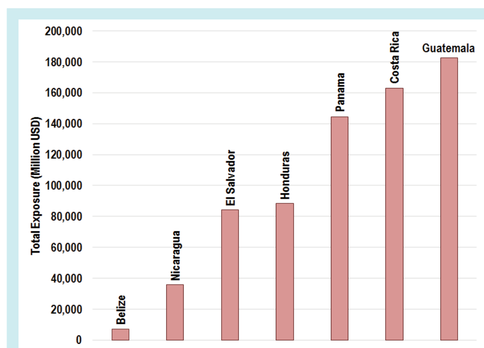
The resulting exposure values are reported in the following figures. The exposure module also provides the distribution of these total values across the residential building stock, the commercial and industrial building stock, and the infrastructure.




Caribbean countries estimated to have a total capital stock of less than 10,000 million USD




Caribbean countries estimated to have a total capital stock between 10,000 and 276,000 million USD




Central American countries

## The VULNERABILITY Module: What happens to the built environment in case of high-intensity rainfall?

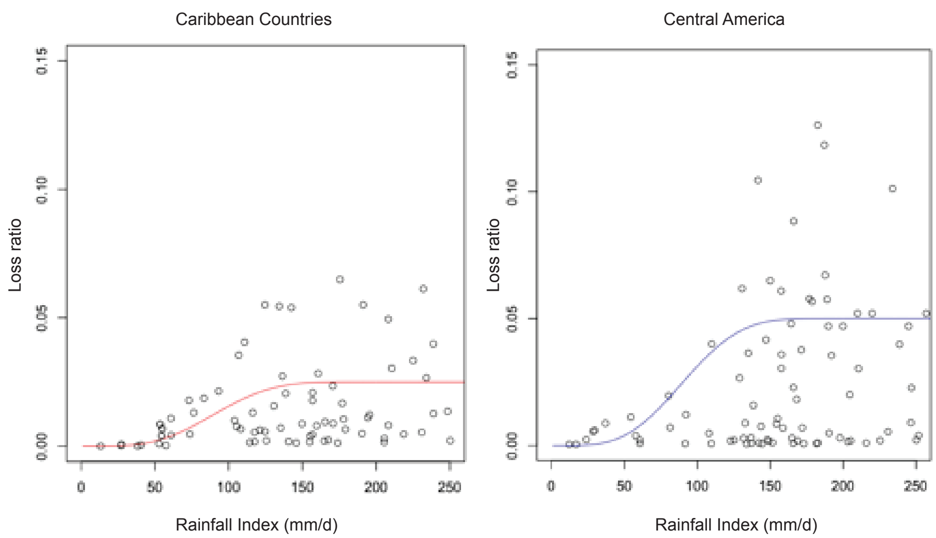
The **archive of historical rainfall-induced regional losses** assembled by CCRIF provides useful information both on the severity and on the spatial and temporal distributions of such losses over the different countries. Based on this database, **vulnerability analyses** were carried out to identify the consequences to the built environment when an excess rainfall event occurs.

The consequences of rainfall are modeled in mathematical terms by means of the so-called **vulnerability functions**, which are relationships that provide estimates of the losses caused by different amounts of precipitation to the assets affected.

### Methodology

The vulnerability functions developed for XSR 2.0 leveraged country-level loss estimates 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 flood-induced portion of total loss for a multi-peril event (the other major peril being wind). Using the reported loss for a country or affected area divided by the replacement cost of the IED developed for XSR 2.0, a regional loss ratio was attributed to an event and assigned to the average aggregated precipitation (mm/day) observed for that event. Because the flooding characteristics of the Caribbean region (smaller countries with smaller flood plains) differ from that of Central America (larger regions with larger flood plains), the averaging time for rainfall accumulation is set to 2 days for Caribbean countries and to 4 days for Central America countries.

### Vulnerability functions




By repeating the exercise for each historical event and each country affected, a range of hazard levels and corresponding damage ratios were derived for each of the two regions. The results are shown above. The vulnerability functions (in blue for Central America and in red for the Caribbean) provide a smoothly varying damage ratio from 0 to approximately 5 per cent at higher rainfall accumulations.

## The LOSS Module: What are the losses caused by an XSR event?

The loss module computes in near-real time after the XSR event has ended whether the precipitation estimated by the hazard module could potentially cause significant losses to the exposure assets that are located in the footprint of the event. Based on rainfall estimates, exposure values in the event footprint and vulnerability functions, the XSR model computes for significant events a synthetic loss index called the **Rainfall Index Loss (RIL)**, which represents the modelled total loss due to the XSR event.

### Methodology

The loss module comprises 3 steps:

1. Covered Area Rainfall Event (CARE) definition
2. Rainfall Loss Index (RIL) computation
3. Characterization of the input to Payout computation

**1. CARE Definition**

The CARE definition is based only on rainfall estimates based on CMORPH, which is the single tool at our disposal that is most likely to detect an XSR event. A CARE event occurs for a given country if threshold values of these 3 parameters are jointly exceeded:

– Aggregation Period (e.g., 2 days for Caribbean countries and 4 days for CA countries)
– Rainfall intensity (e.g., 40 mm/day for a number of days equal to the aggregation period)
– Minimum Cell Fraction (e.g., 15% of all the 1km x 1km exposure cells in a country with rainfall intensity above the threshold for the aggregation period)

This set of threshold values is collectively called the CARE criteria. Once the CARE criteria are met the CARE starts. This is called the CARE start date. The CARE ends when the CARE criteria are no longer met. The day in which the CARE terminates is called the CARE end date. Note that the CARE is not interrupted if the CARE criteria are not met for a country-specific Tolerance Period (TP) (e.g., 1 day for Caribbean countries and 2 days for Central America countries) after the CARE start date. The number of days between the CARE start date and the CARE end date is called the CARE length.

Hence, for each country the definition of a CARE is fully and unambiguously defined by four values: the aggregation period, the rainfall intensity, the minimum cell fraction and the tolerance period. The CARE criteria essentially serve as a primary trigger. If an XSR event does not meet the CARE criteria, the second and the third steps of the methodology will not be executed.

**2. Rainfall Loss Index (RIL) Computation**

RIL computations are performed only for CARE events. The RIL is not computed for rainfall events that do not meet the CARE criteria. RIL computations are carried out using three rainfall estimates extracted from the following models:

1. CMORPH
2. WRF Configuration 1, called WRF1
3. WRF Configuration 2, called WRF2

For each one of the three sets of rainfall estimates the RIL computations are performed according to the procedure in the following paragraph.

For each exposure cell in the country (not just those that activated the CARE) the amount of rain in each aggregation period during the CARE length is extracted from CMORPH and the maximum value is stored (e.g., 120 mm in 2 days). This maximum value averaged over the aggregation period (e.g., 60mm/day) is retained for RIL computation. This value is called the Cell Rainfall Index. This value is used to compute the Cell Loss Rate from the Loss Rate Table (which simply reproduces the vulnerability function in tabular form) published in the policy document. The Cell Loss Rate is multiplied by the value of the public asset exposure in that cell to produce the Cell Loss value. This procedure is repeated for each exposure cell in the country. (Note that for some cells the Cell Loss value may be zero if the rainfall was low or absent.) The RIL for this CARE is simply the sum of the Cell Loss values for all the exposure cells in the country. The procedure above produces three RILs, one for each one of the three rainfall prediction models, namely $RIL_{CMORPH}$, $RIL_{WRF1}$, and $RIL_{WRF2}$. An event for which RILs are computed is called XSR Loss Event.

**3. Payout Input Derivation**

The payout computations for a given country are carried out only for CAREs. The RIL computation provides three RILs and these RILs are used to derive the input to the payout computation procedure. To explain how the input to the payout procedure is derived two definitions are needed:

1. The Loss Threshold (LT), which is a country-specific value. The LT value is always set to be lower than the loss corresponding to the Attachment Point (AP) of the policy condition, i.e. LT<AP. The LT value for a given country is empirically chosen in such a way that the number of historical events for which a RIL is computed is large enough to allow a stable fitting of a statistical distribution that, in turn, is used to estimate RILs rarer than those computed for the 19 years of historical data available from the NOAA models. RILs for rarer events are utilized to estimate appropriate values of the Exhaustion Point (EP) of a policy.

2. Disaster Alert (DA). The DA is an official alert issued by ReliefWeb (http://reliefweb.int/) for severe events of different kinds that occur around the world. ReliefWeb issues alerts for more than 20 types of events ranging from epidemics to earthquakes. The archive of ReliefWeb's disaster alerts starts in 1981 although only since the 1990s has the number of alerts issued been significantly raised. The types of events that concern this XSR insurance product are: tropical cyclone, flood, flash flood and severe local storm. All major XSR-related events that affected the Caribbean countries and the Central America countries have had disaster alert issued by ReliefWeb.

In essence, the LT and DAs serve as secondary triggers. The input to the payout computation is derived differently according to the following three cases:

1. The Rainfall Index Loss based on CMORPH rainfall estimates and at least one Rainfall Index Loss based on the two WRF configurations are above the Loss Threshold.

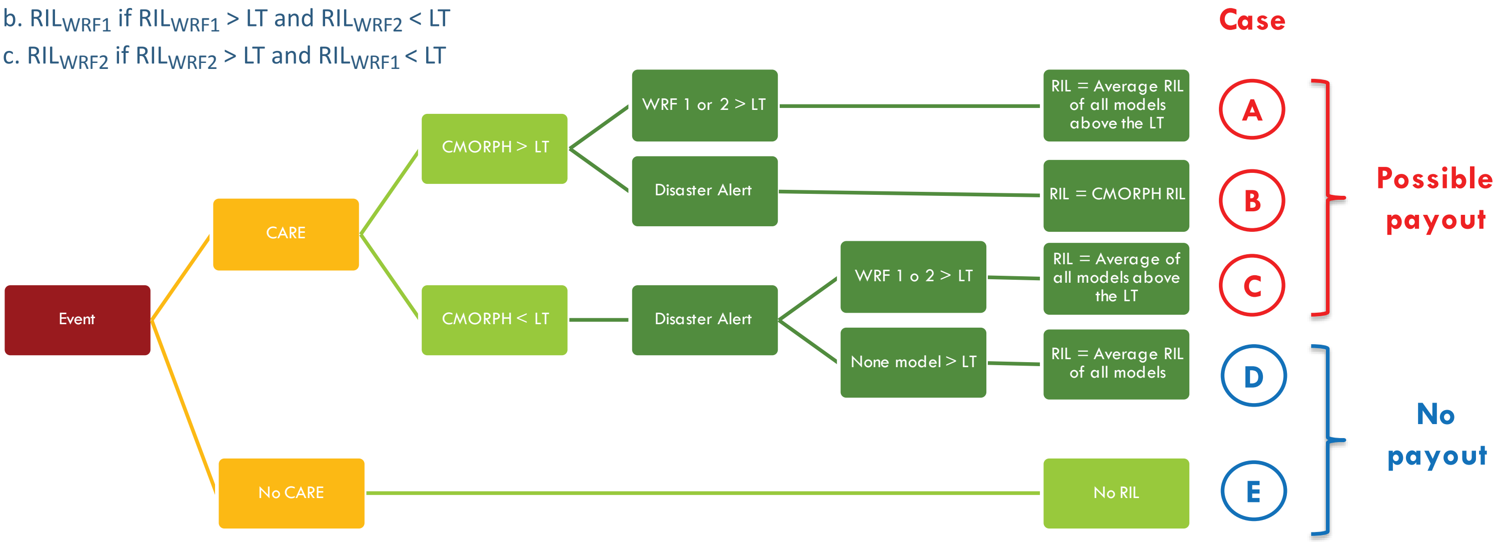
$RIL_{CMORPH} > LT$ and $RIL_{WRF1}$ or $RIL_{WRF2} > LT \rightarrow$ payout is computed using the average of all the RILs that exceed LT as input, namely

a. $(RIL_{CMORPH} + RIL_{WRF1})/2$ if $RIL_{WRF1} > LT$ and $RIL_{WRF2} < LT$
b. $(RIL_{CMORPH} + RIL_{WRF2})/2$ if $RIL_{WRF1} < LT$ and $RIL_{WRF2} > LT$
c. $(RIL_{CMORPH} + RIL_{WRF1} + RIL_{WRF2})/3$ if $RIL_{WRF1} > LT$ and $RIL_{WRF2} > LT$

2. The Rainfall Index Loss based on CMORPH rainfall estimates is above the Loss Threshold, the ones associated to the two WRF configurations are below the Loss Threshold, but a Disaster Alert is issued.
$RIL_{CMORPH}$> LT, $RIL_{WRF1}$ and $RIL_{WRF2}$ <LT but DA issued → payout is computed using $RIL_{CMORPH}$

3. The Rainfall Index Loss based on CMORPH rainfall estimates is below the Loss Threshold, but a Disaster Alert is issued.
$RIL_{CMORPH}$< LT but DA issued → payout is computed using the average of all the RILs that exceed LT, namely
a. ($RIL_{WRF1}$ + $RIL_{WRF2}$)/2 if both $RIL_{WRF1}$ and $RIL_{WRF2}$ > LT
b. $RIL_{WRF1}$ if $RIL_{WRF1}$ > LT and $RIL_{WRF2}$ < LT
c. $RIL_{WRF2}$ if $RIL_{WRF2}$ > LT and $RIL_{WRF1}$ < LT

Note that for completeness, another subcase of Case 3 exists, that is a DA is issued but all the three RILs are below the LT. This could be the case, for example, with tropical cyclones that cause mostly wind as opposed to rain damage or tropical cyclones whose amount of rainfall is underestimated by the model. In this case an RIL is computed as the average of the three RILs but this operation will lead to a situation in which the RIL is less than the LT and less than the Attachment Point (RIL<LT<AP) and, therefore, no payout would be due.



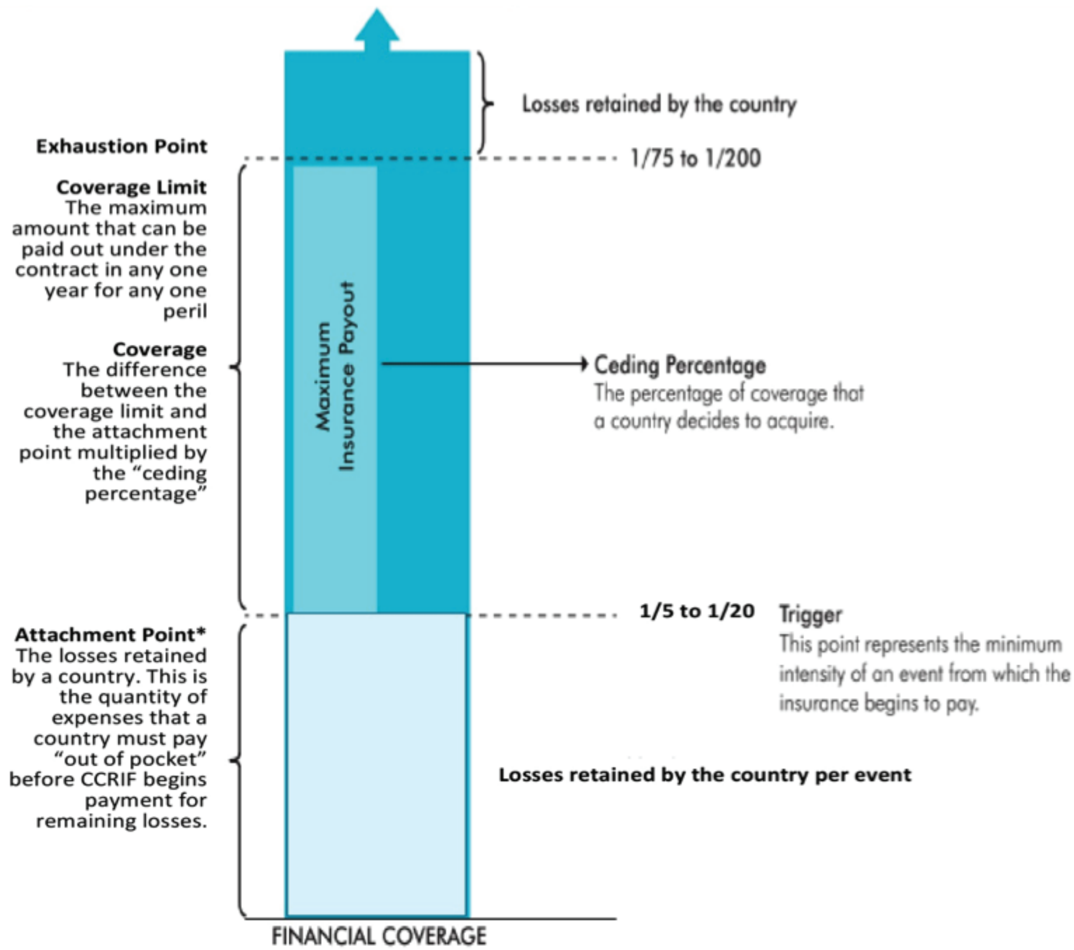

## The INSURANCE Module: Which parameters determine the payout of an XSR event?

The insurance module uses the model loss estimates to compute the payout to each country affected by an XSR Loss Event. More precisely, in all the three cases (a, b and c) of the RIL computation as described in the previous section, the final RIL is compared with the values of the AP and the EP of the policy. If RIL<AP then the payout is zero otherwise the payout is computed using the customary approach described below.

The payout depends on the values of a set of four parameters specified in the XSR insurance policy of each insured country:
**The Attachment Point (AP)** represents the loss that a country decides to retain before any insurance payout begins and is similar to a "deductible" in a standard insurance policy.
**The Exhaustion Point (EP)** is the loss value at which the full insurance payout is due.
**The Ceding Percentage (CP)** is the fraction of the difference between the exhaustion point and the attachment point that the insured country transfers to CCRIF.
**The Coverage Limit (CL)** is the maximum amount that can be paid out to an insured country in any one year of coverage.

A country's policy is triggered only when the RIL for the XSR event is equal to or exceeds the attachment point and, therefore, there is no payout below this point. If the RIL is greater than the AP then the payout is computed in two steps. First the Event Payout Rate is calculated as follows, expressed as a percentage: (RIL – AP) / (EP – AP). Then the payout equals the lesser of: (a) the Event Payout Rate multiplied by the Coverage Limit, or (b) the Event Payout Limit. In respect of any Insured Event, the Event Payout Limit is defined as the Coverage Limit less any policy payments previously made during the policy period. The maximum payout that an insured country can receive after any XSR event is equal to the exhaustion point minus the attachment point times the ceding percentage (see figure below).

The values of these four insurance policy parameters, which are selected by the countries, are crafted to provide the best possible coverage that meets the country's risk mitigation needs. Once the attachment point and exhaustion point are chosen, there is a one-to-one relationship between the amount of premium paid and the ceding percentage – a higher ceding percentage means a higher premium.




*The attachment point can be described as the minimum severity of the event loss which gives rise to a payment and therefore is the loss value at which the policy contract is triggered. The attachment point therefore functions like a deductible in a standard insurance policy.

## Why are Risk Transfer Tools Becoming Increasingly Important?

Risk transfer mechanisms constitute an important part of disaster risk management (DRM) and climate resilience strategies. It is important for countries to engage in a range of strategies to reduce their vulnerabilities and to develop dynamic and first-class DRM policies and strategies. Risk transfer mechanisms must therefore be seen as one part of a country's broader DRM policy mix.

The use of risk transfer mechanisms constitutes pre-event planning and ensures that countries take a proactive, comprehensive and sustained approach to DRM. These types of mechanisms are becoming increasingly important and an indispensable component of economic policy and disaster risk management strategies as countries seek to grow their economies, reduce poverty and become internationally competitive.

CCRIF SPC
The Caribbean Catastrophe Risk Insurance Facility

## About CCRIF

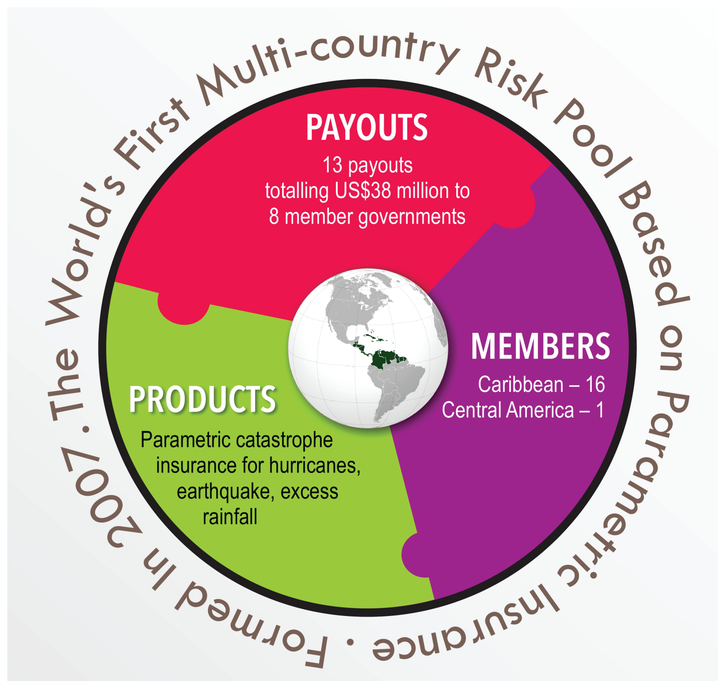
In 2007, the Caribbean Catastrophe Risk Insurance Facility was formed as the first multi-country risk pool in the world, and was the first insurance instrument to successfully develop parametric policies backed by both traditional and capital markets. It was designed as a regional catastrophe fund for Caribbean governments to limit the financial impact of devastating hurricanes and earthquakes by quickly providing financial liquidity when a policy is triggered.

In 2014, the facility was restructured into a segregated portfolio company (SPC) to facilitate offering new products and expanding into geographic areas and is now named CCRIF SPC. The new structure, in which products are offered through a number of segregated portfolios, allows for total segregation of risk.

In 2015, CCRIF expanded to Central America, when CCRIF and COSEFIN (the Council of Ministers of Finance of Central America, Panama and the Dominican Republic) signed a Memorandum of Understanding to provide catastrophe insurance to Central American countries. Also at that time, Nicaragua signed a Participation Agreement, becoming the first CCRIF member from Central America.

CCRIF currently offers earthquake, tropical cyclone and excess rainfall policies to Caribbean and Central American governments. Since the inception of CCRIF in 2007, the facility has made 13 payouts totalling approximately US$38 million to 8 member governments.

CCRIF was developed under the technical leadership of the World Bank and with a grant from the Government of Japan. It was capitalized through contributions to a Multi-Donor Trust Fund by the Government of Canada, the European Union, the World Bank, the governments of the UK and France, the Caribbean Development Bank and the governments of Ireland and Bermuda, and membership fees paid by participating governments. The Central American SP is capitalized by a contributions to a special Multi-Donor Trust Fund by the World Bank, European Union and the governments of Canada and the United States.




The current members of CCRIF are:
Caribbean – Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts & Nevis, Saint Lucia, St. Vincent & the Grenadines, Trinidad & Tobago and Turks & Caicos Islands
Central America – Nicaragua

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