The CCRIF Excess Rainfall (XSR) Model

The CCRIF Excess Rainfall (XSR) Model and XSR Product

Caribbean and Central American countries face a number of primary natural hazard risks, particularly earthquake and hurricane risks. Secondary risks such as those from flooding and landslides, storm surge and wave impacts, and tsunamis also pose significant threat. 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 natural hazards will be exacerbated by climate change. Climate change is expected to lead to more frequent high-intensity hurricanes, accelerating the erosion of coastal beaches, inundation of low-lying land and loss of protective mangroves. Climate change also is expected to increase rainfall variability. Greater, and therefore more damaging, precipitation during storms and other peak periods will be juxtaposed with more frequent and longer droughts.

From as far back as 2010, Caribbean governments expressed strong interest in CCRIF developing and making available an excess rainfall product to complement the existing hurricane and earthquake products and as a means of reducing their excess 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 totalling US$5.8 million to four of these member countries.

Currently, CCRIF is modifying the existing rainfall model to improve the model estimates and the structure of the excess rainfall policy. The new model will be the CCRIF Excess Rainfall Model 2.0. The XSR model 2.0 is aimed at simulating in real time the precipitation over a country and rapidly estimating the potential consequent losses such that shortly after the end of the XSR event the country can receive a payout consistent with the CCRIF insurance policy conditions if that country's rainfall policy is triggered.

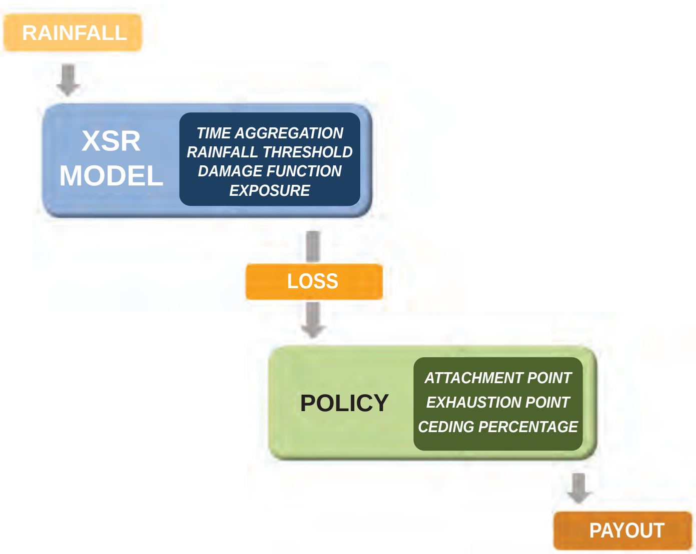
Unlike traditional parametric insurance products that are based only on event parameters, the XSR model estimates rainfall-induced losses to the built environment. The XSR model is a flexible tool that provides options for managing a portion of the identified risk according to the financial needs of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

Components of the CCRIF XSR Model 2.0

The XSR Model is made up of the following modules:

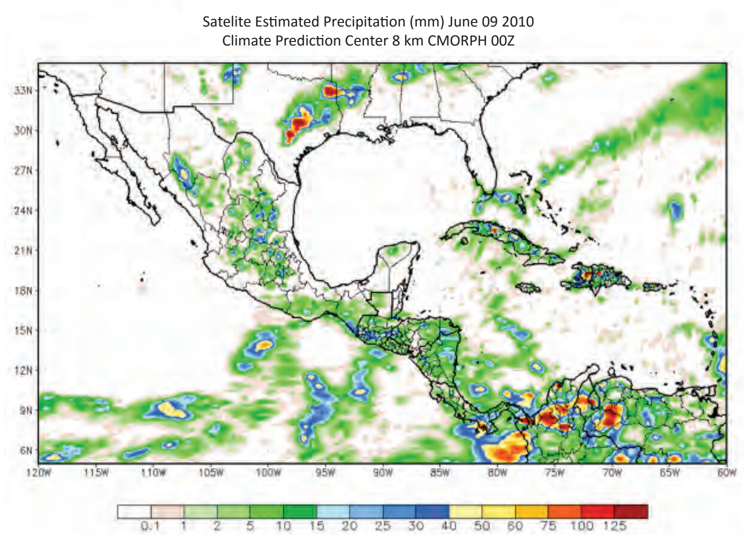
- **Exposure Module,** which describes the built environment in each country
- **Hazard Module**, which estimates the aggregated amount of a rainfall event over the most affected part of a country during the period of the storm (i.e. aggregation time)
- **Vulnerability Module**, which establishes relationships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

The conceptual flow of the XSR Model is shown in the figure below.



The HAZARD Module: How frequent are XSR events?

The hazard module provides on a daily basis the 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 NCEP[1] model and WRF[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]). The NCEP and WRFmodels, 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 a statistical technique is applied that combines the rainfall estimates based on both the forecast model simulations and on the satellite data. An example of daily rainfall estimates for June 9, 2010 predicted using CMORPH is shown in the figure below.



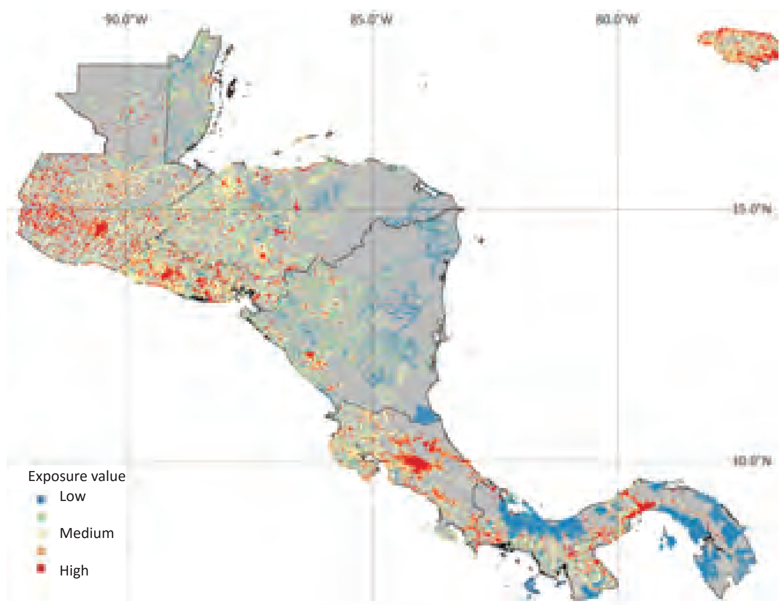
An XSR event is determined by the amount of average rainfall over an accumulation period ranging from 2 to 4 days over a sufficiently large part of a country. The number of accumulation days and value of the average rainfall amount are country-specific.

Although this procedure yields global precipitation estimates at high resolution, they are downscaled to cells 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 the high resolution of the exposure database of the XSR Model.

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

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

The exposure dataset is comprised of 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, night-time lights, population censuses, Digital Elevation Maps (DEM), 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 for the following sectors: residential buildings, commercial buildings, industrial facilities, hotels and restaurants, healthcare facilities, education assets, airports and ports, and the transportation (road) network. 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).** Photos of buildings that can be found in the region and the density of replacement cost of buildings in the six Central America countries are shown below.



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

The archive of historical rainfall-induced regional losses that has been assembled by CCRIF provides useful information both on the severity and on the spatial and temporal distributions of such losses over 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 caused by an XSR event to the exposed assets affected.

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 a synthetic loss index called the Rainfall Index Loss (RIL), which represents the modelled losses due to the XSR event.

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. The payout depends on the values of a set of parameters specified in the XSR insurance policy of each insured country:

The **Attachment Point** 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.

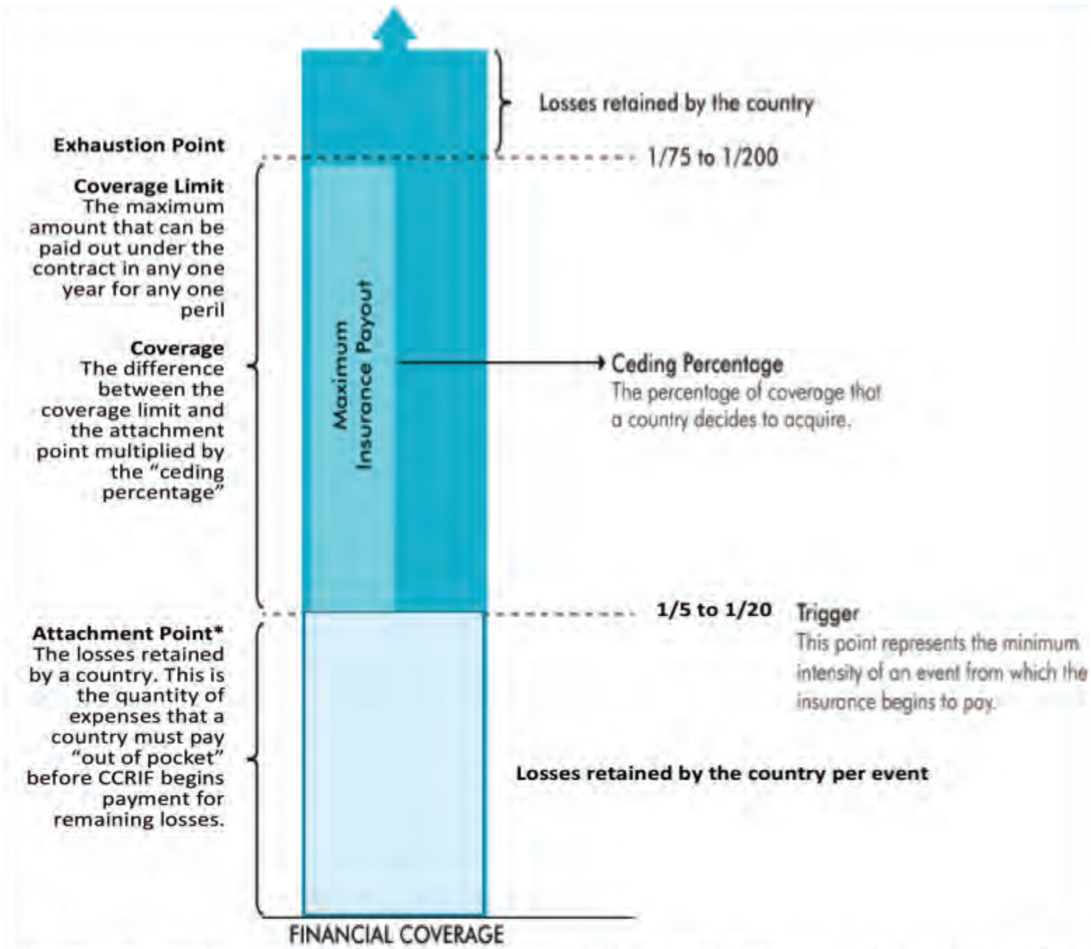
The **Exhaustion Point** is the loss value at which the full insurance payout is due.

The **Ceding Percentage** is the fraction of the difference between the exhaustion point and the attachment point that the insured country transfers to CCRIF.

The **Coverage Limit** 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 modelled loss for the XSR event is equal to or exceeds the attachment point and therefore there is no payout below this point.

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 insurance policy parameters 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.

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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