CCRIF SPC
The Caribbean Catastrophe Risk Insurance Facility

On behalf of
Caribbean XSR SP

Covered Area Rainfall Event (22/09/2019 to 24/09/2019)

Excess Rainfall

Event Briefing

Trinidad and Tobago - Tobago

2 October 2019

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1 INTRODUCTION

Karen was the twelfth tropical cyclone in the 2019 Atlantic Hurricane Season. On 22 September it developed as a tropical storm to the northeast of Trinidad and Tobago. On the same day, it passed over the waters between Grenada and Saint Vincent and the Grenadines at a distance of approximately 45 km from both countries. These islands were affected by tropical-storm-force winds. On the following day, Karen left the Windward Islands moving towards the northwest across the southeastern Caribbean Sea.

The Government of Trinidad and Tobago has two separate Excess Rainfall policies – one for Trinidad and one for Tobago.

This event briefing describes the impact on the island of Tobago, which is associated with the Rainfall Index Loss (RIL) calculated for this Covered Area Rainfall Event (CARE), starting on 22 September and ending on 24 September 2019. This RIL indicated government losses above the attachment point of the Excess Rainfall policy for Tobago. Final calculations show that a payout of US$362,982 is due.

The Excess Rainfall policy for Trinidad was not triggered by this event due to the low amount of precipitation in areas with high density of exposure active grid cells and therefore no payout is due on this policy.

2 EVENT DESCRIPTION

On 22 September at 0900UTC, the US National Hurricane Center (NHC) reported that the low pressure system located to the northeast of Trinidad and Tobago developed as a tropical storm, and it was named Karen (Figure 1). The minimum central pressure was estimated at 1005 mb and the centre of circulation was located at 11.9N, 60.2W, approximately 47 mi (77 km) NE of Tobago and 100 mi (165 km) E of Grenada. The maximum sustained winds were estimated at 40 mph (65 km/h) and tropical-storm-force winds extended about 125 miles (205 km) outward from the centre.

The system was moving towards the west northwest along the southwestern periphery of the Bermuda-Azores high pressure system located over the Atlantic Ocean. Its forward velocity was estimated at 9 mph (15 km/h) and it was directed towards the southern Windward Islands.

In the following hours, the intensification of the tropical storm was hindered by the presence of dry air and northeasterly wind shear and after 6 hours, at 1500UTC, the force of the tropical storm was approximately unchanged. At this time, the centre of the tropical storm was located at 12.5N 61.7W, it while was over the waters between Grenada and Saint Vincent and the Grenadines at a distance of approximately 30 mi (45 km) from both countries. Afterwards, the tropical storm left the Windward Islands, moving across the southeastern Caribbean Sea towards the northwest at the same forward velocity.

Since its development at 0900UTC, the tropical storm presented a poorly organized and fragmented pattern of convection, as shown by the satellite image in Figure 2. Nevertheless, two intense plumes of convection were active over Tobago in the period between 1030UTC and 1430UTC (Figure 2). The radar maps from the ground radar sited over Trinidad showed

the persistent precipitation associated with the thunderstorms affecting Tobago during this period (Figure 3). The reflectivity maps showed that the rainfall was moderate and locally intense over this island during this period. Moreover, the radar maps showed moderate precipitation affecting Tobago a few hours before the upgrade of the low pressure system to a tropical storm, starting from 0500UTC. Other convective cells and associated showers developed over the waters surrounding Trinidad. Precipitation affected mainly the areas offshore of Trinidad and the coastal parts, while the internal part of the island was only marginally affected.

The surface measurements from the GSOD dataset (Global Surface Summary of the Day - *https://www1.ncdc.noaa.gov*) reported data from only one rain gauge over Tobago, located at the Robinson International Airport (11.15N, 60.84W) near Crown Point at the southeastern edge of the island. The station recorded a total amount of precipitation of 67mm during this precipitation event (from 20 to 24 September). Approximately the same amount of precipitation was recorded by the GSOD rain gauge station over Trinidad. The gauge was located at Piarco International Airport (10.58N, 61.31W) in the north-centre of the Island and it measured an accumulated precipitation of 80 mm during this event.

The satellite-derived estimate of precipitation by IMERG (Integrated Multi-satellitE Retrievals for GPM) dataset for this event is reported in Figure 4. During the period 20 - 24 September, the accumulated precipitation over Tobago was estimated in the interval between 100 and 160 mm, with lower values over the southern coast and higher values over the northern one.

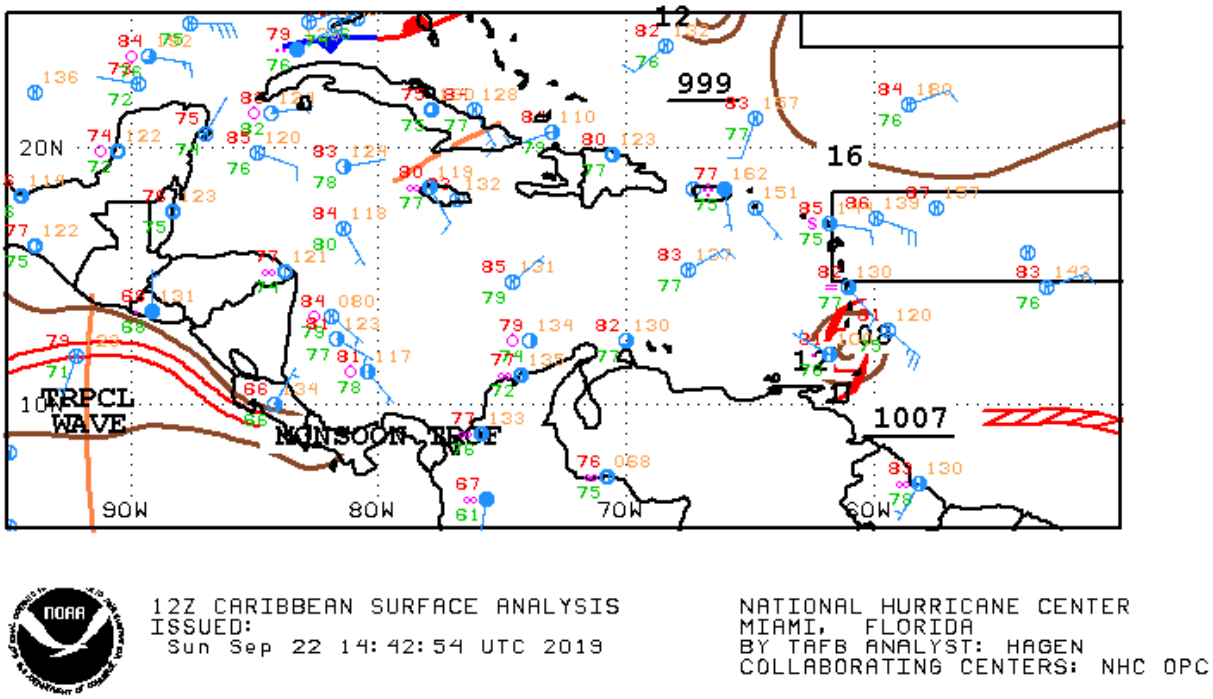
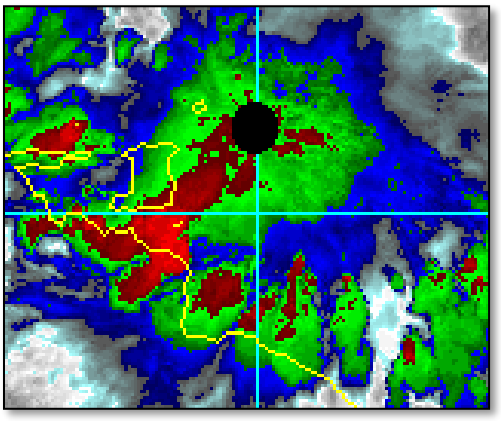
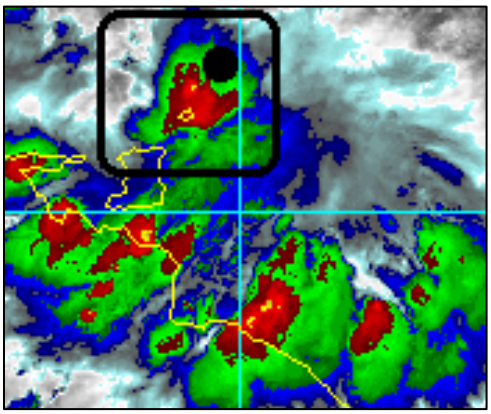


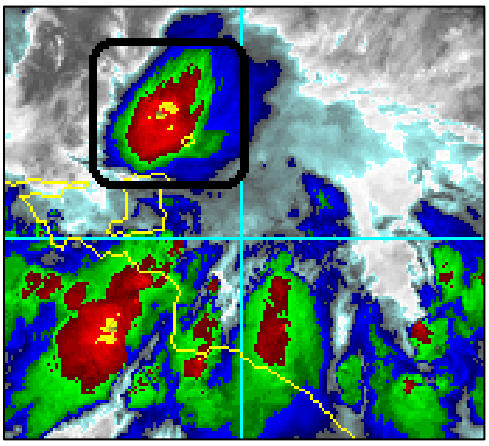
Figure 1 Surface analysis over the Caribbean area on 22 September at 1200UTC. The tropical storm is visible over the southern Windward Islands Source: US National Hurricane Center (NHC)



a) 22 September at 0900UTC

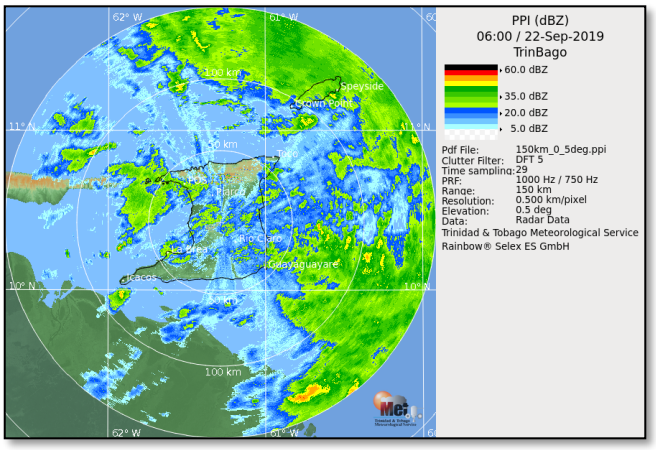


b) 22 September at 1100UTC

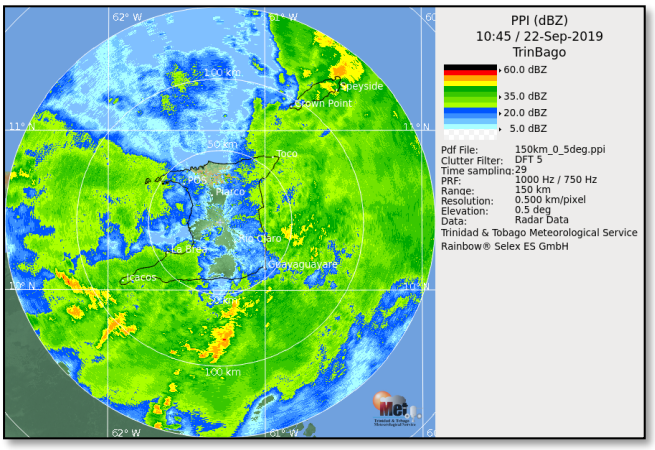


c) 22 September at 1300UTC

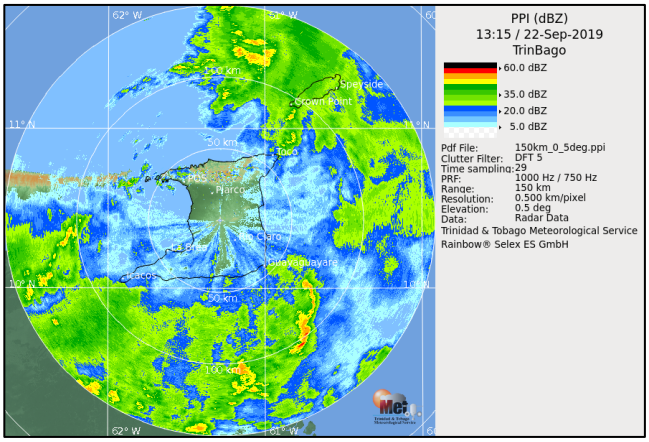
Figure 2 Satellite imagery on 22 September at different times as indicated in the labels from thermal infrared channel enhanced with colour. Blue/green colours represent high altitude clouds (top cloud temperature between -50°C and -70°C), while the red colour represents very high altitude clouds (top cloud lower than -70°C). High altitude clouds indicate strong convection associated with intense precipitation. The centre of tropical storm Karen is indicated by the black dot and the persistent thunderstorm indicated by the black box. Source: NOAA, National Environmental Satellite, Data and Information Service



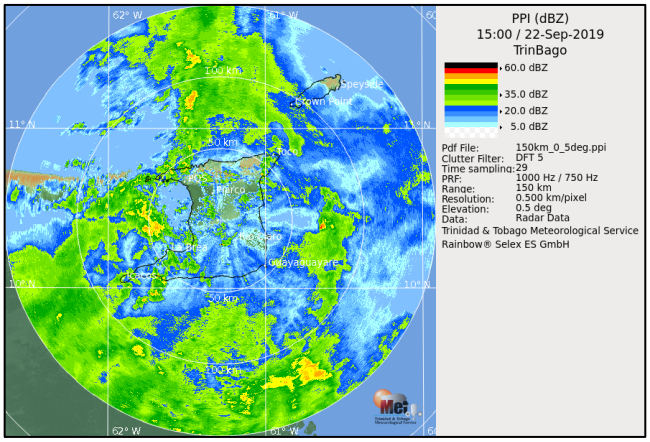
a) 22 September 0600UTC



b) 22 September 1045UTC



c) 22 September 1315UTC



d) 22 September 1500UTC

Figure 3 Reflectivity maps from the radar centered over Trinidad at different times on 22 September 2019 as indicated by the labels. Colors indicate the reflectivity, function of the intensity of precipitation (green colours are for moderate, while yellow/red are for intense)

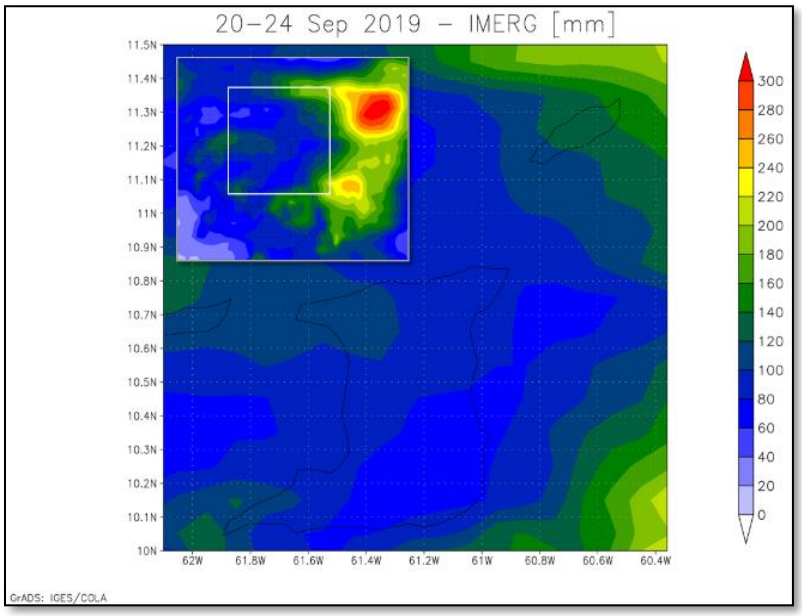


Figure 4 IMERG accumulated precipitation (rainfall) at 10 km resolution over Trinidad and Tobago in the period 20 to 24 September 2019. Source: XSR Web

3 IMPACTS

At the time of this report and according to a preliminary evaluation from the Tobago Emergency Management Agency (TEMA), due to the impacts of Tropical Storm Karen, there were several villages across Tobago without electricity and communication services. The affected communities include: Hope, Roxborough, Pembroke, Belle Garden and Mt. St. George. Reports indicated that the schools and airports were closed.

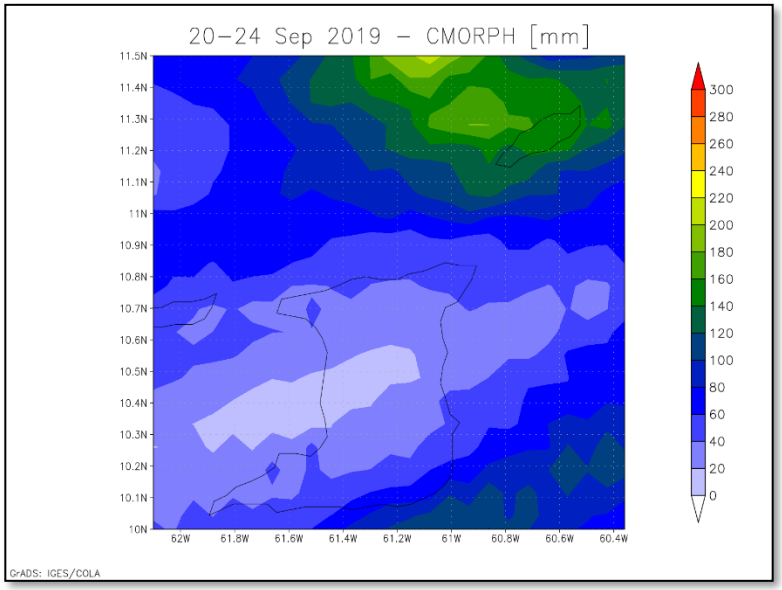
Figure 5 shows some flood damage caused by heavy rainfall in Tobago.

Figure 4 Damage caused by heavy rainfall in Tobago – September 2019. Source: *Daily Express*

4 RAINFALL MODEL OUTPUTS

All three models, CMORPH[1], WRF5 and WRF7[2], simulated the occurrence of showers over Trinidad and Tobago and the surrounding waters during the period 20-24 September 2019.

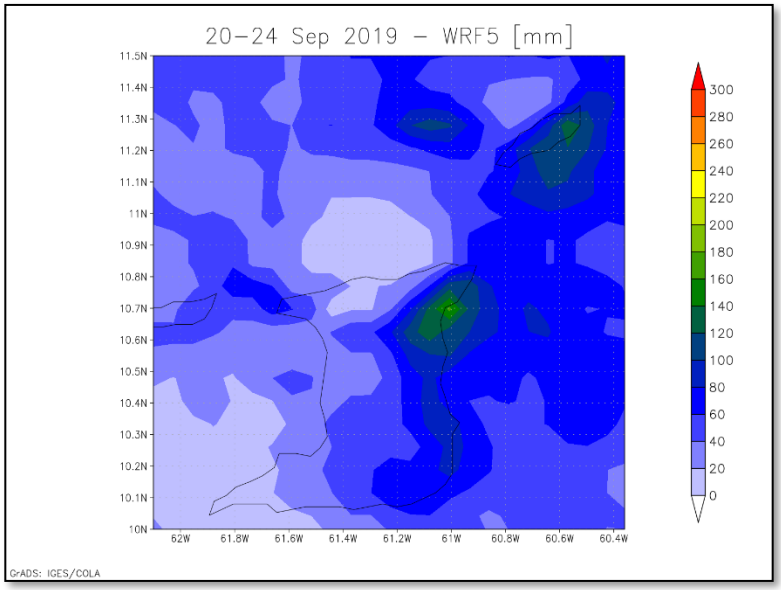
CMORPH reported total accumulated amounts of precipitation comparable or higher than those of IMERG over Tobago, between 120 mm and 160 mm, with the maximum in the centre of the island. Both WRF simulations produced lower amounts of precipitation than CMORPH: between 60 mm and 120 mm for WRF5 and between 20 mm and 80 mm for WRF7. All three data sources used by XSR 2.5 reported values of rainfall for Trinidad, generally between 0 mm and 60 mm, with a localized higher peak (only for WRF5 and WRF7) on the northeast coast in an area characterized by low exposure.



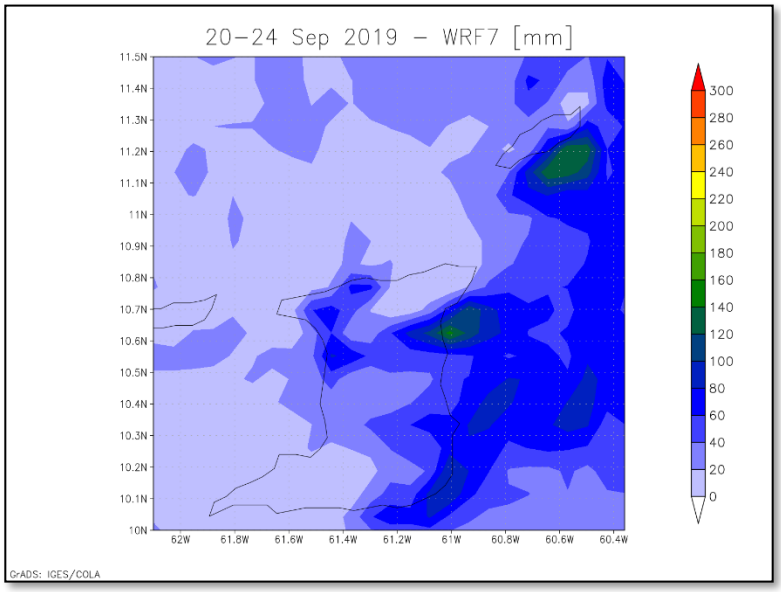
a) CMORPH

[1] CMORPH Model: the satellite-based rainfall precipitation estimates provided by the NOAA Climate Prediction Center (CPC) using the so-called Morphing Technique *http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html*. Further details in the Definitions section of this report.

[2] WRF5 and WRF7 Models: the Weather Research and Forecasting Model weather model-based Configuration #1 and #2 data *https://www.mmm.ucar.edu/weather-research-and-forecasting-model*. These data are initialised by the NCEP FNL dataset. (NCEP FNL Operational Model Global Tropospheric Analyses [*http://rda.ucar.edu/datasets/ds083.2/*]). Further details in the Definitions section of this report.



b) WRF5



c) WRF7

Figure 5 Total accumulated precipitation during the period 20-24 September 2019 estimated by CMORPH (a), WRF5(b) and WRF7(c)

Daily rainfall maps by CMORPH, WRF5 and WRF7 over the exposure map of XSR 2.5 are not included here; they can be downloaded at the following links for 12-hour aggregation and 48-hour aggregation respectively:

http://redrisk.webfactional.com/OUTPUT/CCRIF/XSR/Events/TTO/TTO_TOB/CARE_5_2019/daily_prec_short.mp4

http://redrisk.webfactional.com/OUTPUT/CCRIF/XSR/Events/TTO/TTO_TOB/CARE_5_2019/daily_prec_long.mp4

The Rainfall Index Loss (RIL) was above the loss threshold for Tobago for two of the data sources used by XSR 2.5, i.e. for CMORPH and WRF5. The largest RIL was associated with CMORPH, given that it reported a higher amount of rainfall over areas characterized by large exposure. The final RIL (RIL_{FINAL}) was calculated as the average of the RILs from these two data sources. The RIL_{FINAL} was higher than the policy attachment point for the Excess Rainfall policy for Tobago, and therefore this event was classified as a triggering event thus resulting in a payout. The XSR2.5 did not identified this event as a CARE event for the Excess Rainfall policy for Trinidad due to the low amount of precipitation reported by CMORPH in areas with high density of exposure active grid cells. Therefore, the RIL_{FINAL} was not calculated for this event for Trinidad.

5 TRIGGER POTENTIAL

The Rainfall Index Loss was calculated for this Covered Area Rainfall Event (CARE) that started on 22 September and ended on 24 September 2019, producing government losses which were above the attachment point of Trinidad and Tobago's Excess Rainfall policy for Tobago. Final calculations show that a payout of US$362,982 is due.

CCRIF expresses empathy with the Government and people of Trinidad and Tobago for the impacts on communities and infrastructure caused by this event.

For further information, please contact ERN-RED, the CCRIF SPC Risk Management Specialist at the official email: monitor.xsr2@ccrif.org

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DEFINITIONS

Active Exposure Cell Percentage Threshold	The percentage of the total number of XSR Exposure Grid Cells within the Covered Area of the Insured, that must be exceeded to trigger a Covered Area Rainfall Event.
Active Exposure Grid Cells	The XSR Exposure Grid Cells for which in the same single day the Aggregate Rainfall #1 value computed using the CMORPH-based Rainfall Estimate equals or exceeds the Rainfall Event Threshold #1 or the Aggregate Rainfall #2 value computed using the CMORPH-based Rainfall Estimate equals or exceeds the Rainfall Event Threshold #2.
Aggregate Rainfall #1	The rainfall amount accumulated over the Rainfall Aggregation Period #1 (as defined in the Schedule) measured in millimeters (mm) in any of the XSR Exposure Grid Cells in the Covered Area of the Insured. For a given day and a Rainfall Aggregation Period #1 of n hours, the Aggregate Rainfall #1 is the maximum amount of rainfall accumulated over any of the n-hour windows that intersect the day itself considering a time interval of 3 hours.
Aggregate Rainfall #2	The rainfall amount accumulated over the Rainfall Aggregation Period #2 (as defined in the Schedule) measured in millimeters (mm) in any of the XSR Exposure Grid Cells in the Covered Area of the Insured. For a given day and a Rainfall Aggregation Period #2 of n hours, the Aggregate Rainfall #2 is the maximum amount of rainfall accumulated over any of the n-hour windows that intersect the day itself considering a time interval of 3 hours.
Calculation Agent	Entity charged with undertaking the primary calculation of the Rainfall Index Loss.
CMORPH-based Maximum Aggregate Rainfall #1	The maximum value during the Covered Area Rainfall Event of the Aggregate Rainfall #1 computed using the CMORPH-based Rainfall Estimates in any given XSR Exposure Grid Cell over the Covered Area of the Insured.
CMORPH-based Maximum Aggregate Rainfall #2	The maximum value during the Covered Area Rainfall Event of the Aggregate Rainfall #2 computed using the CMORPH-based Rainfall Estimates in any given XSR Exposure Grid Cell over the Covered Area of the Insured.
CMORPH-based Covered Area Rainfall Parameters	The CMORPH Model information provided on a continuous basis by the XSR Model Data Reporting Agency used by the Calculation Agent to obtain the CMORPH-based Rainfall

	Estimates using the XSR Rainfall Model. Parameters are drawn from XSR Exposure Grid Cells within the Covered Area of the Insured, by their respective latitude and longitude. Measurement units and precision of data ingested by the XSR Rainfall Model are identical to those provided by the XSR Model Data Reporting Agency and are further elaborated in the Attachment entitled 'Calculation of Rainfall Index Loss and Policy Payment'.
CMORPH Model	The satellite-based rainfall estimation model provided by NOAA CPC as described in the Rainfall Estimation Models section of the Policy.
Covered Area	The territory of the Insured as represented in the XSR Rainfall Model.
Covered Area Rainfall Event	Any period of days, with an interruption less than or equals to the Event Tolerance Period, during which the number of Active Exposure Grid Cells is greater than or equal to the product of (a) Active Exposure Cell Percentage Threshold multiplied by (b) the total number of XSR Exposure Grid Cells within the Covered Area.
Country Disaster Alert	An official disaster alert issued by ReliefWeb (*http://reliefweb.int/*) for the country in question for one of the following types of events: tropical cyclone, flood, flash flood and severe local storm. Any disaster alert issued later than seven (7) days after the completion of the Covered Area Rainfall Event (CARE) event will not be considered. The Disaster Alert description issued by ReliefWeb and/or its attached documentation must include specific reference to the CARE dates with a tolerance period of 2 calendar days.
Maximum Aggregate Rainfall #1	The highest value during a Covered Area Rainfall Event of the Aggregate Rainfall #1 amount in any of the XSR Exposure Grid Cells in the Covered Area of the Insured computed.
Maximum Aggregate Rainfall #2	The highest value during a Covered Area Rainfall Event of the Aggregate Rainfall #2 amount in any of the XSR Exposure Grid Cells in the Covered Area of the Insured computed.
Rainfall Event Threshold #1	Aggregate Rainfall #1 level as defined in the Schedule which should be exceeded to trigger an Active Exposure Cell.
Rainfall Event Threshold #2	Aggregate Rainfall #2 level as defined in the Schedule which should be exceeded to trigger an Active Exposure Cell.

Rainfall Aggregation Period #1	The number of hours over which the Aggregate Rainfall #1 is computed for all XSR Exposure Grid Cells during a Covered Area Rainfall Event.
Rainfall Aggregation Period #2	The number of hours over which the Aggregate Rainfall #2 is computed for all XSR Exposure Grid Cells during a Covered Area Rainfall Event.
Rainfall Index Loss	For any Covered Area Rainfall Event affecting the Insured, the US Dollar loss calculated by the Calculation Agent using the XSR Rainfall Model, as described in the Attachment entitled 'Calculation of Rainfall Index Loss and Policy Payment'. The Rainfall Index Loss can only be calculated once the Covered Area Rainfall Event is completed.
WRF5 Model	The weather research and forecasting rainfall model by NOAA with Configuration #5 data initialized with and assimilating the data provided by the National Center for Environmental Prediction as described in the Rainfall Estimation Models and in the Input Data to the Rainfall Estimation Models sections of this Attachment.
WRF7 Model	The weather research and forecasting rainfall model by NOAA with Configuration #7 data initialized with and assimilating the data provided by the National Center for Environmental Prediction as described in the Rainfall Estimation Models and in the Input Data to the Rainfall Estimation Models sections of this Attachment.
XSR Rainfall Model	The computer model used to calculate the Rainfall Index Loss, as described in the Attachment entitled 'Calculation of Rainfall Index Loss and Policy Payment'.
XSR Exposure Grid Cells	The 30 arc-second by 30 arc-second grid of cells each of which is attributed with an XSR Grid Cell Exposure Value greater than zero.
XSR Grid Cell Exposure Value	The value, used to calculate the CMORPH-based Exposure Grid Cell Loss, the WRF5-based Exposure Grid Cell Loss, and the WRF7-based Exposure Grid Cell Loss.