CCRIF SPC
The Caribbean Catastrophe Risk Insurance Facility

On behalf of
Caribbean XSR SP

# Covered Area Rainfall Event (29-30 September 2016)

# Tropical Cyclone Matthew Excess Rainfall

## Event Briefing
## Dominica

**11 October 2016**

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## 1 INTRODUCTION

In late September 2016 a tropical storm formed in the eastern Caribbean, and during its path evolved into a category 5 hurricane named Matthew. The storm, moving towards the west, affected the Lesser Antilles between 28 and 30 September bringing tropical cyclone force winds, storm surge and heavy rainfall to Barbados, Saint Lucia, St. Vincent & the Grenadines, Dominica and Grenada. During its erratic path the storm strengthened in the centre of the Caribbean Sea and changed direction to the north affecting the Greater Antilles region as a major Hurricane, between 3 and 6 October, affecting Jamaica, Haiti, Cuba, Turks & Caicos Islands, The Bahamas, and the East Coast of the United States, causing heavy rainfall and major hurricane force winds and storm surge.

This report describes the results of the Caribbean Rainfall Model on CCRIF member country Dominica. Other reports are being issued regarding other CCRIF member countries that have Excess Rainfall policies.

The Caribbean Rainfall Model (operated by RED – Risk Engineering + Design, part of the CCRIF Risk Management Specialist Team) indicated that a Covered Area Rainfall Event (CARE) was generated in Dominica, starting on 29 September and ending on 30 September 2016.

As a consequence of the heavy rainfall from Tropical Cyclone Matthew over Dominica, the Rainfall Index Loss (RIL) calculated for this CARE was below the Attachment Point of Dominica´s Excess Rainfall policy and therefore no payout is due.

## 2 EVENT DESCRIPTION

A tropical wave passing through the Windward Islands acquired a close circulation on 28 September as shown in the analysis chart in Figure 1, on the left. At 1500 UTC Tropical Cyclone Matthew was located at 13.4° N and 60.7° W with a minimum estimated central pressure of 1008 hPa and maximum sustained winds of 57 mph (92.5 km/h). The analysis charts below show the forecasted tropical storm/hurricane track (red arrow followed by tropical storm/hurricane symbol).

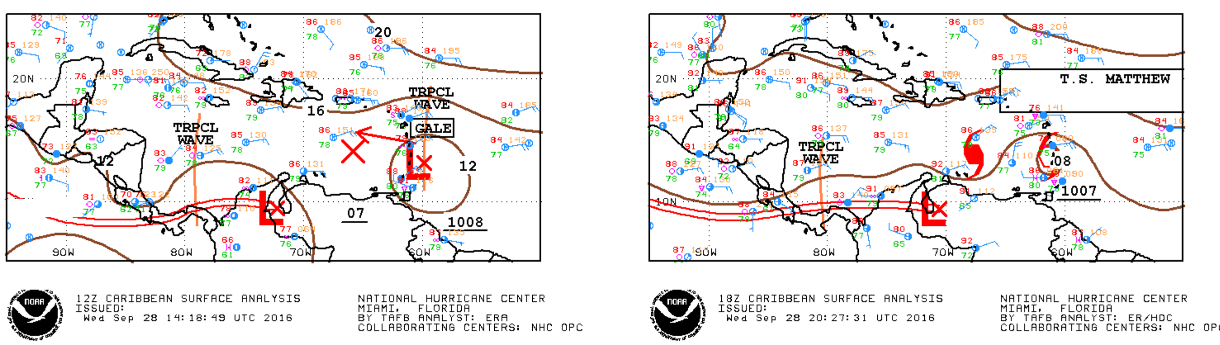
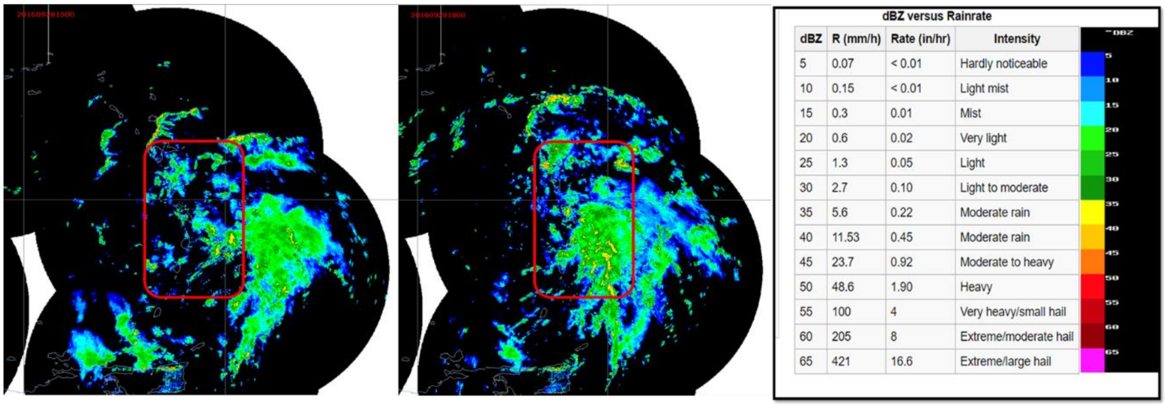



*Figure 1 – National Hurricane Center surface analysis chart of 28/09/2016 at 12 UTC (left) and 18 UTC (right).*

The first precipitation associated with the tropical wave affected the Lesser Antilles on the morning of 28 September. The following reflectivity maps from a Caribbean radar composite, which have a direct correlation with precipitation, give a complete overview of the meteorological event as it occurred.

Precipitating systems were organized in narrow bands that moved in a predominantly westward direction (Figure 2, left). At 1100 UTC, systems began to be more organized and spread out, with a well-defined rotating movement (Figure 2, right).



**dBZ versus Rainrate**

| dBZ | R (mm/h) | Rate (in/hr) | Intensity |
|---|---|---|---|
| 5 | 0.07 | < 0.01 | Hardly noticeable |
| 10 | 0.15 | < 0.01 | Light mist |
| 15 | 0.3 | 0.01 | Mist |
| 20 | 0.6 | 0.02 | Very light |
| 25 | 1.3 | 0.05 | Light |
| 30 | 2.7 | 0.10 | Light to moderate |
| 35 | 5.6 | 0.22 | Moderate rain |
| 40 | 11.53 | 0.45 | Moderate rain |
| 45 | 23.7 | 0.92 | Moderate to heavy |
| 50 | 48.6 | 1.90 | Heavy |
| 55 | 100 | 4 | Very heavy/small hail |
| 60 | 205 | 8 | Extreme/moderate hail |
| 65 | 421 | 16.6 | Extreme/large hail |

*Figure 2 – Reflectivity maps of Caribbean radar composite (source:* **http://barbadosweather.org/Composite/**) *centred over Lesser Antilles at 04:45 UTC (left) and 11:00 UTC (centre) reflectivity relationship table (right).*

At 1500 UTC, the nucleus of the system reached the Lesser Antilles (Figure 3). In the following hours the cyclone intensified.

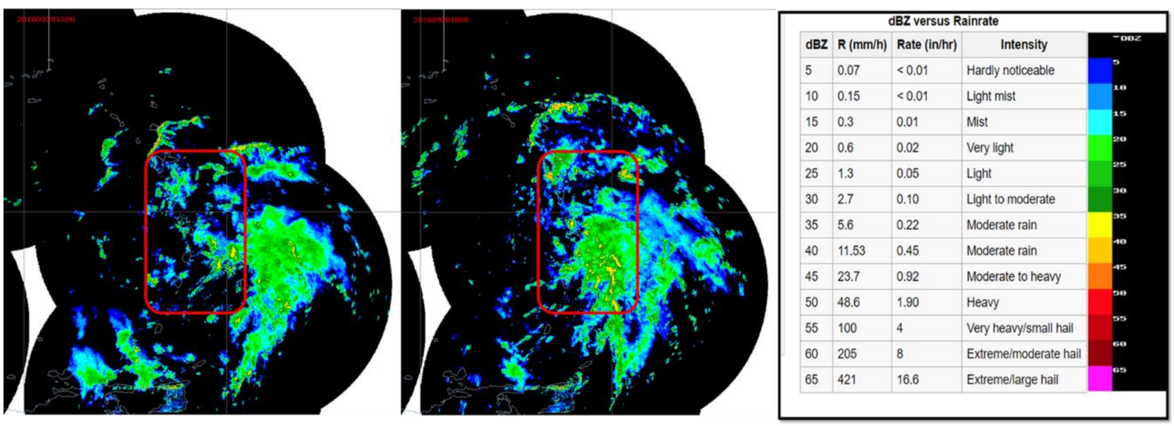


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*Figure 3 – Reflectivity maps of Caribbean radar composite (source:* **http://barbadosweather.org/Composite/**) *centred over Lesser Antilles at 15:00 UTC (left) and 18:00 UTC (centre) reflectivity relationship table (right).*

Up to 0300 UTC on 29 September, Tropical Cyclone Matthew affected, with great rainfall persistency, all southern Windward Islands due to its slow westward movement as shown by the image sequence of Figure 4. The greater impact was on the islands between Dominica and Saint Vincent and the Grenadines (Figure 5).

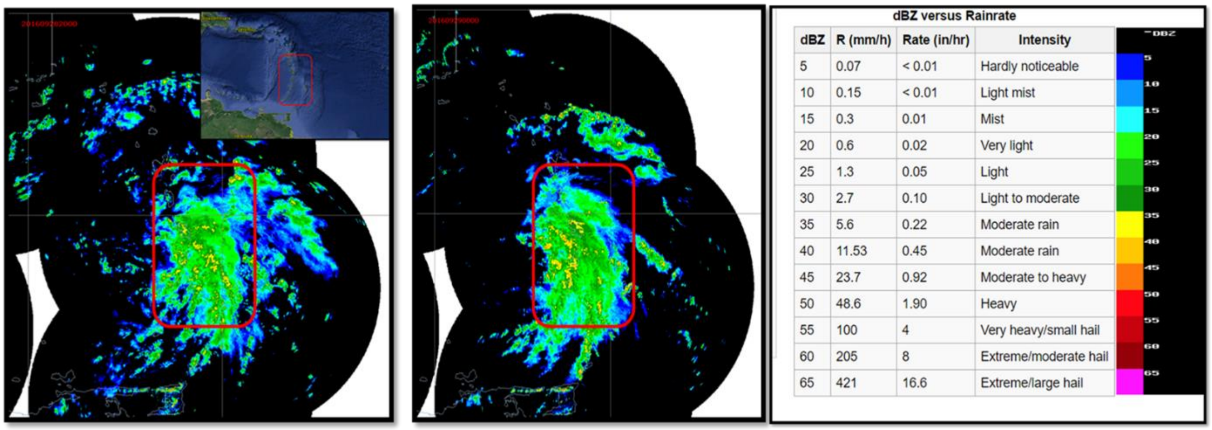

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*Figure 4 – Reflectivity maps of Caribbean radar composite (source:* **http://barbadosweather.org/Composite/***) centred over the Lesser Antilles at 2000 UTC, 2200 UTC on 28 September and 0000 UTC and 0200 UTC on 29 September.*

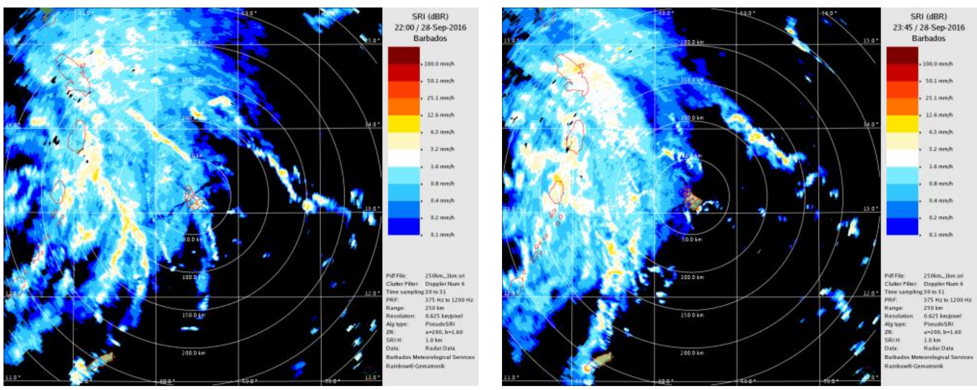


*Figure 5 – Rainfall intensity maps from Barbados radar (source:* **http://barbadosweather.org/RadarPro/***) at 2200 UTC (left) and 2359 UTC (right) on 28 September.*

Stronger rain phenomena over the island of Barbados (Figure 6) ended at 0030 UTC on 29 September, and were followed by small and localized precipitating systems associated with rainbands during the first hours of 29 September.

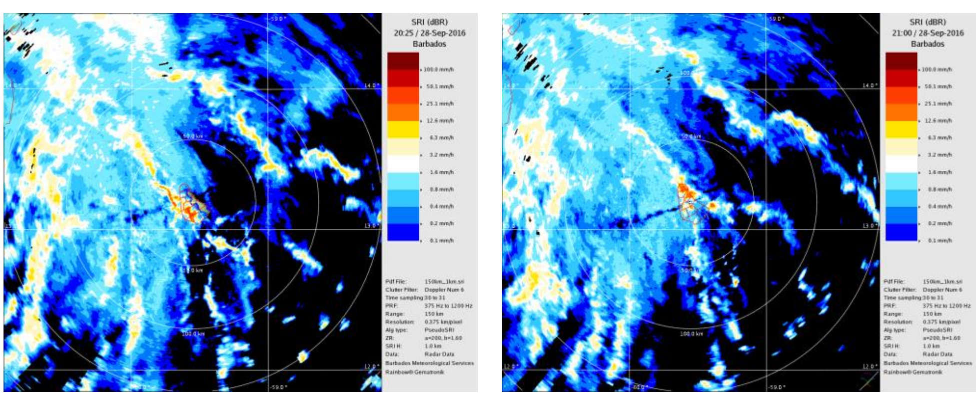


*Figure 6 – Rainfall intensity maps from Barbados radar (source:* **http://barbadosweather.org/RadarPro/***) at 2025 UTC (left) and 2100 UTC (right) on 28 September.*

As depicted by the surface analysis at 0000 UTC on 29 September, a strong subtropical ridge over the Atlantic steered Tropical Cyclone Matthew westward (Figure 7). This caused a reduction in rainfall after 0300 UTC.

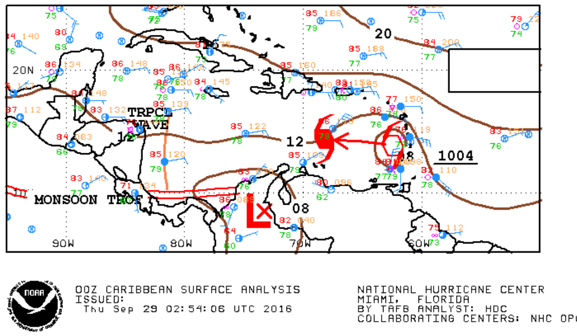


*Figure 7 – National Hurricane Center surface analysis chart of 29/09/2016 at 0000 UTC.*

On 29 September, from 0700 UTC to 1400 UTC, a reinforcement of precipitation phenomena was observed. The most intense part of the system affected Barbados, Saint Lucia and Saint Vincent & the Grenadines islands. Dominica and Grenada resulted less affected by precipitation (Figure 8). In particular, rainfall over Dominica ceased at about 1200 UTC.

Accumulated precipitation of approximately 188 mm/24 h was recorded at Hewanorra Airport (Saint Lucia) over 28-29 September (source: ECHO Daily map).

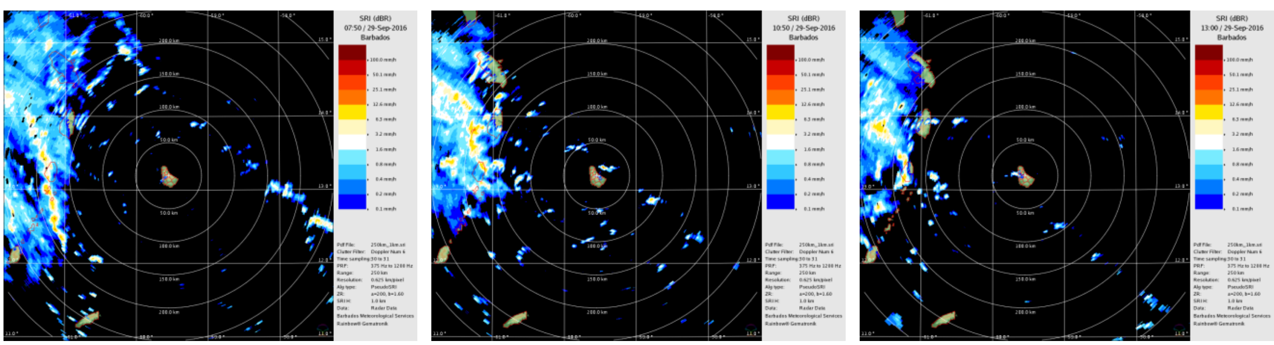

*Figure 8 – Rainfall intensity maps from Barbados radar (source:* **[http://barbadosweather.org/RadarPro/](http://barbadosweather.org/RadarPro/)***) at 0730 UTC (left), at 1050 UTC (center) and 1300 UTC (right) on 29 September.*

Tropical Cyclone Matthew continued its movement towards the west while strengthening. At 1800 UTC on 29 September Matthew was upgraded to a Hurricane, but, at that time, had limited effect on the considered domain. The last precipitation was recorded over Grenada from 1500 UTC to the end of the day.

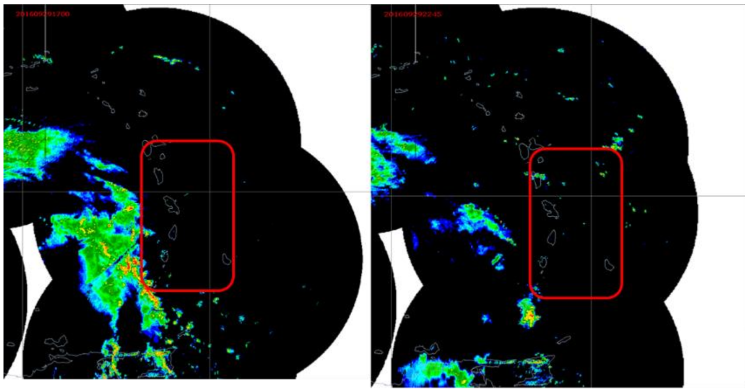

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*Figure 9 – Reflectivity maps of Caribbean radar composite (source: http://barbadosweather.org/Composite/) centered over Lesser Antilles at 17:00 UTC (left) and 22:45 UTC (right) of 29 September.*

# 3 IMPACTS

According to the Caribbean Disaster Emergency Management Agency (CDEMA), Dominica received moderate to heavy rainfall and strong winds induced by TC Matthew. Flash flooding, landslides, blocked roads and down power lines were reported across the island, and there was some damage to residential roofs and agricultural areas, with one house totally destroyed.

Five persons stayed in shelters but there were no reports of deaths or injuries.

*Figure 10 Damages due to TC Matthew.  Source: www.dominicanewsonline.com*

# 4 RAINFALL MODEL ANALYSIS

Due to the lack of surface observations, model results were compared to the STAR Satellite Rainfall Estimates provided by the US National Oceanic and Atmospheric Administration (NOAA). The Hydro-Estimator (H-E) product uses infrared (IR) data from NOAA's Geostationary Operational Environmental Satellites (GOES) to estimate rainfall rates with a high spatial resolution of 4 km. The accumulated 24-hour estimates are updated every day at 1215 UTC. As a consequence of this data temporal resolution, the accumulated rain from 1200 UTC on 29 September to 1200 UTC on 30 September is used to analyze model results.

To give an overview of the intensity of the event as it occurred, Figure 11 shows the pattern of accumulated estimated rainfall centered over the Windward Islands.

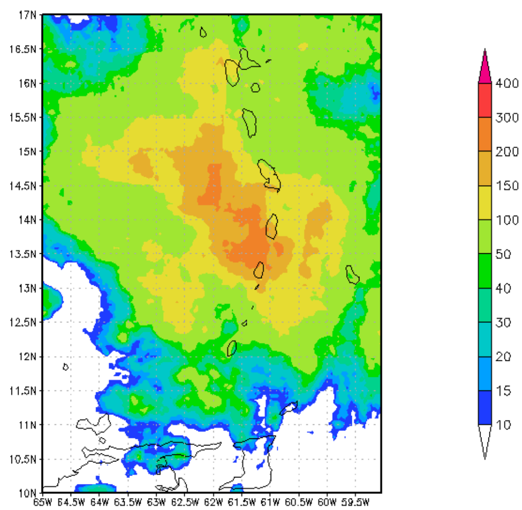


*Figure 11 – Satellite-derived accumulated rainfall (in mm) from 1200 UTC on 28 September to 1200 UTC on 29 September over the Windward Islands.*

For this event neither CMORPH datasets nor the second WRF configuration (WRF2), run in XSR2.0, identified the loss event. However, the first configuration of WRF (WRF1) estimated high intensity precipitation associated with Tropical Cyclone Matthew. The great difference that can be recognized between satellite-derived accumulation and WRF1 is that maximum values are located, in the first case, on the west side of islands, while in the second case on the east side (Figure 12). The three datasets show fewer differences at the north and south parts of the displayed domain. The reason for this behaviour may be that the cyclone passed in the center of the domain shown and the ends were less affected by intense precipitation.

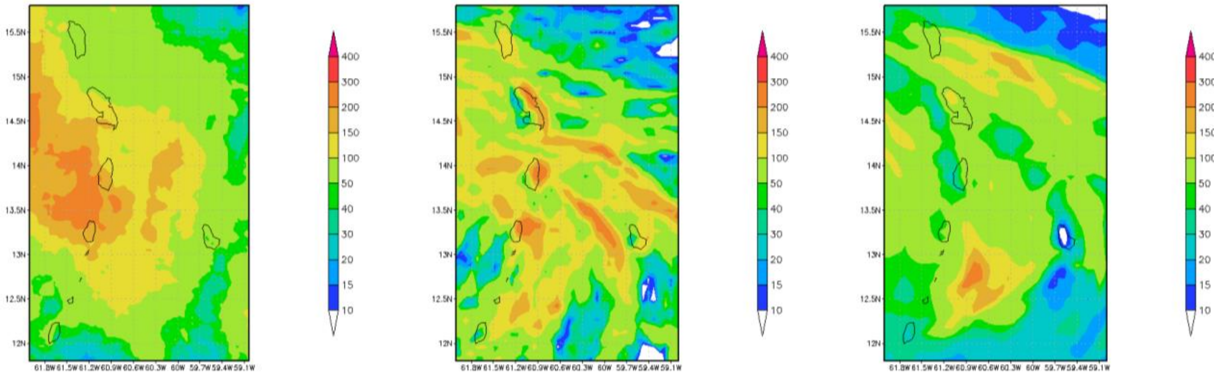

*Figure 12 – Accumulated rainfall (in mm) from 1200 UTC on 28 September to 1200 UTC on 29 September over the Windward Islands: satellite-derived (left), WRF1 (centre) and WRF2 (right).*

Regarding Dominica, the main difference in satellite-derived precipitation can be found in the displacement of the highest values, which for WRF1 are localized over the island. Satellite-based values all reside in the range between 50 and 100 mm, while for WRF1 they range between 50 and 150 mm.

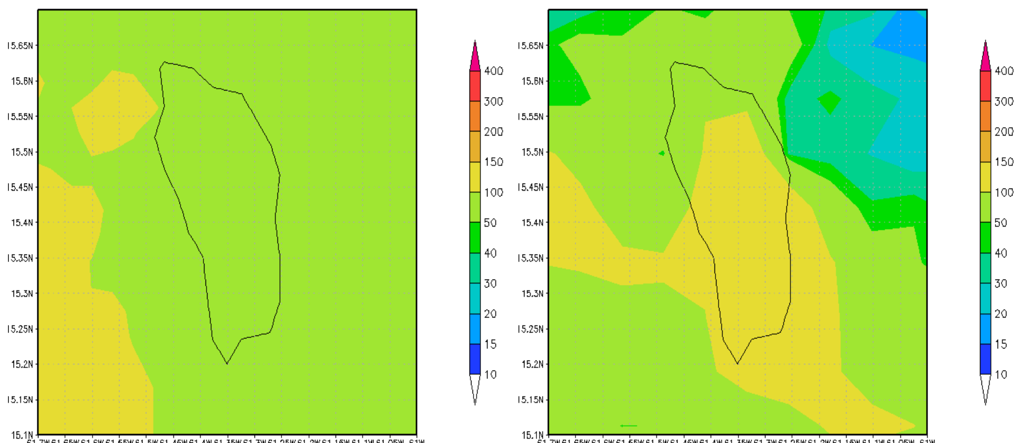

*Figure 13 – Accumulated rainfall (in mm) from 1200 UTC on 28 September to 1200 UTC on 29 September over Dominica: satellite-derived (left) and WRF1 (right).*

# 5 TRIGGER POTENTIAL

The Rainfall Index Loss (RIL) calculated for this CARE was below the Attachment Point of Dominica´s Excess Rainfall policy and therefore no payout is due.

For further information, please contact ERN-RED, the CCRIF SPC Risk Management Specialist.

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**DEFINITIONS**

| | |
|---|---|
| **Active Exposure Cell Percentage Threshold** | The percentage of the total number of XSR Exposure Grid Cells as defined in the Schedule, with in the covered Area of the Insured which when exceeded triggers a Covered Area Rainfall Event |
| **Active Exposure Grid Cells** | The XSR Exposure Grid Cells for which in the same single day the Average Aggregate Rainfall value computed using the CMORPH-based Rainfall Estimate equals or exceeds the Rainfall Event Threshold. |
| **Average Aggregate Rainfall** | The Average Aggregate Rainfall amount (where the number of days in the Rainfall Aggregation Period is defined in the Schedule) as measured in millimeters per day (mm/day) in any of the XSR Exposure Grid Cells in the Covered Area of the Insured. For a given number of days n, the n-day aggregation period is the average of rainfall on the day itself and on the previous n-1 days. |
| **Calculation Agent** | Entity charged with undertaking the primary calculation of the Rainfall Index Loss as described in the Calculation Agency Agreement. |
| **CMORPH-based Maximum Average Aggregate Rainfall** | The maximum value during the Covered Area Rainfall Event of the Average Aggregate Rainfall computed using the CMORPH-based Daily 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 Daily Rainfall Estimates using the XSR Rainfall Model. Parameters are drawn from XSR Exposure Grid Cells within the Covered Area of the Insured as identified in the Cell Identification and Rainfall Exposure Value Table in the Schedule, 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 |

| | |
|---|---|
| **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 event will not be considered. |
| **Maximum Average Aggregate Rainfall** | The highest value during a Covered Area Rainfall Event of the Average Aggregate Rainfall amount in any of the XSR Exposure Grid Cells in the Covered Area of the Insured computed. |
| **Rainfall Event Threshold** | Average Aggregate Rainfall level as defined in the Schedule which should be exceeded to trigger an Active Exposure Cell. |
| **Rainfall Aggregation Period** | The number of days over which the Average Aggregate Rainfall 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. |

| | |
|---|---|
| | the Attachment entitled 'Calculation of Rainfall Index Loss and Policy Payment' |
| **WRF1 Model** | The weather research and forecasting rainfall model by NOAA with Configuration #1 data initialized 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 the Policy. |
| **WRF2 Model** | The weather research and forecasting rainfall model by NOAA with Configuration #2 data initialized 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 the Policy. |
| **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, as provided in the Schedule. |
| **XSR Grid Cell Exposure Value** | The value, as shown in the Cell Identification and Rainfall Exposure Value Table in the Schedule, used to calculate the CMORPH-based Exposure Grid Cell Loss, the WRF1-based Exposure Grid Cell Loss, and the WRF2-based Exposure Grid Cell Loss. |