Covered Area Rainfall Event
(4-5 August 2016)

Tropical Cyclone Earl
Excess Rainfall

Event Briefing

19 August 2016

1   INTRODUCTION

In early August 2016 a tropical storm formed in the central Caribbean and evolved into a category 1 hurricane named Earl on 3 August. The storm moved to the west increasing strength just before impacting the northern Central America region, bringing tropical cyclone force winds and storm surge to Belize and Honduras on 4 August as well as heavy rainfall over Guatemala, Honduras, Belize and Mexico. 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 CCRIF member country Belize, starting on 4 August and ending on 5 August 2016.

As a consequence of the heavy rainfall from Tropical Cyclone Earl over Belize, the Rainfall Index Loss (RIL) calculated for this CARE was above the Attachment Point of Belize´s Excess Rainfall policy and therefore the policy was triggered, indicating that a payout of US$261,073 is due.

Note that, as reported in a previous briefing on Tropical Cyclone Earl issued on 5 August, Belize's Tropical Cyclone policy was not triggered and therefore no payout was due on that policy.

2   EVENT DESCRIPTION

Tropical Storm Earl formed over the central Caribbean, south of Grand Cayman, on 2 August. It was associated with scattered and isolated strong convection (Figure 1). The initial estimated central pressure was 1002 hPa. In the analysis charts below, the forecasted tropical storm/hurricane track (red arrow followed by tropical storm/hurricane symbol) is shown.
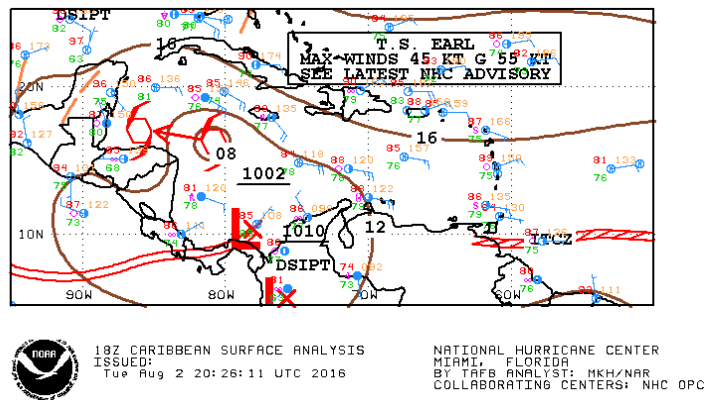

Figure1 - National Hurricane Center surface analysis chart at 20UTC on 02/08/2016

During successive hours Earl moved towards the west (Figure 2), intensifying. On 3 August, strong convection was observed off the coast of Honduras.
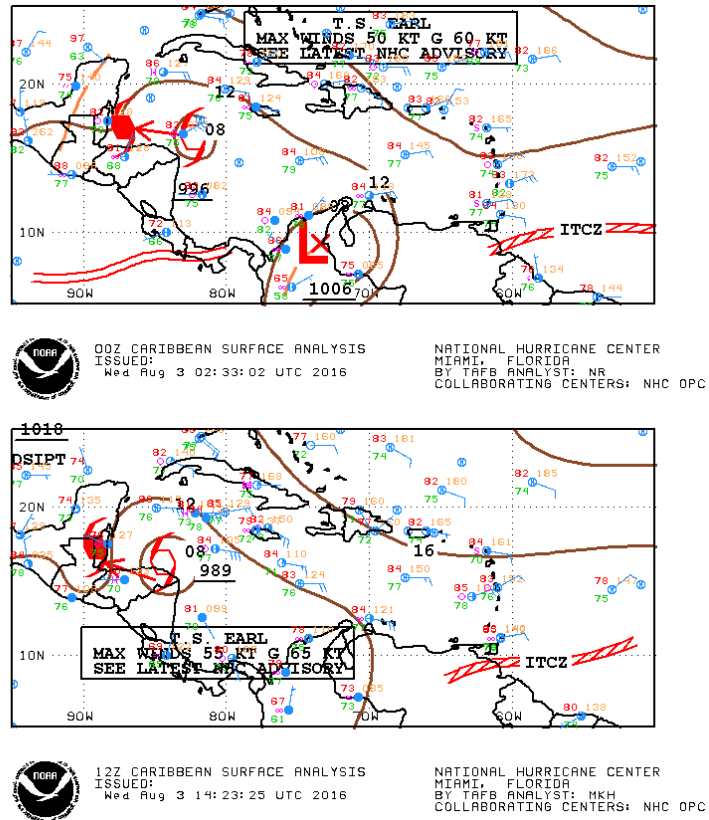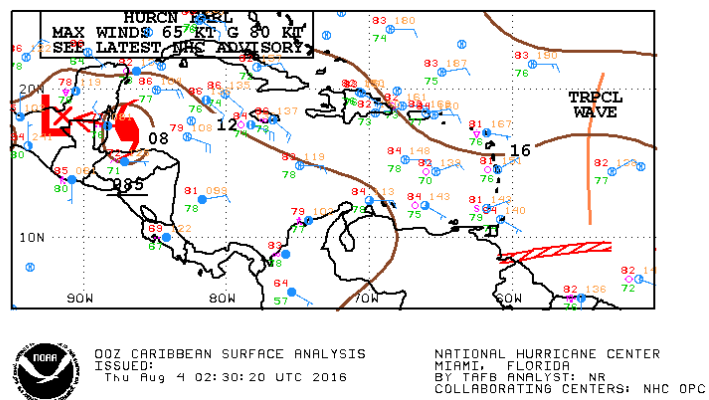
Figure 2 - National Hurricane Center surface analysis chart at 02UTC (top) and 14UTC (bottom) on 03/08/2016

At 21UTC the tropical storm was upgraded to a category 1 hurricane. The estimated minimum central pressure dropped from 1002 hPa on 2 August to 979 hPa at 06UTC on 4 August when the hurricane was over Belize and reached its minimum central pressure. Maximum sustained winds reached a maximum value of 130 km/h (80 mph) at 05UTC (Figure 3).
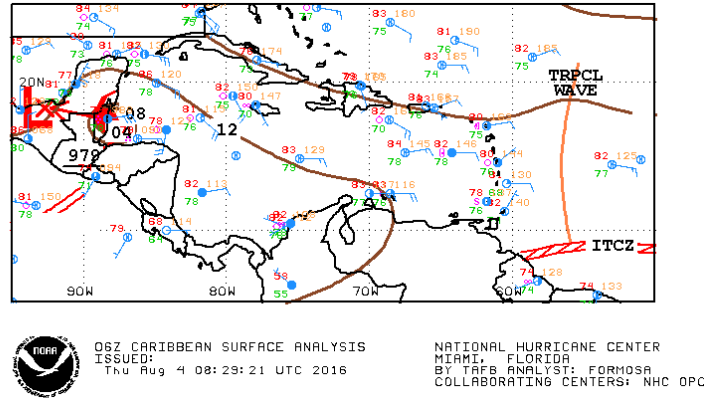
Figure 3 - National Hurricane Center surface analysis chart at 02UTC (top) and 08UTC (bottom) on 04/08/2016

The following tables provide wind speed values recorded by Belize's National Meteorological Service.

Station	Max. 5-minute Wind Speed (kt)	Max. 5-minute Wind Speed (km/h)	Max. 5-minute Wind Speed (mph)
Half Moon Caye	64.6	119.6	74.3
San Pedro, Ambergris Caye	47.3	87.6	54.4
Port of Belize	54.4	100.7	62.6
International Airport	40.9	75.7	47.0
Belmopan	27.2	50.4	31.3
Baldy Beacon, Mountain Pine Ridge	65.4	121.1	75.2
Dangriga	31.7	58.7	36.5
Placencia	20.4	37.8	23.5

Station	Day and Time of occurrence	Maximum Gust (kt)	Maximum Gust (km/h)	Maximum Gust (mph)
Half Moon Caye	2016/08/04 04:00UTC	90.4	167.4	104.0
San Pedro, Ambergris Caye	2016/08/04 05:56UTC	63.3	117.2	72.8
Port of Belize	2016/08/04 07:14UTC	69.5	128.7	79.9
International Airport	2016/08/04 05:11UTC	63.3	117.2	72.8
Belmopan	2016/08/04 07:25UTC	39.4	73.0	45.3
Baldy Beacon, Mountain Pine Ridge	2016/08/04 09:55UTC	84.6	156.7	97.3

| Dangriga | 2016/08/04 07:35UTC | 48.7 | 90.2 | 56.0 |
| Placencia | 2016/08/04 07:25UTC | 34.5 | 63.9 | 39.7 |

Station	Day and Time of Occurrence	Max 1-minute Wind Speed (kt)	Max 1-minute Wind Speed (km/h)	Max 1-minute Wind Speed (mph)
Half Moon Caye	2016/08/04 04:00UTC	not available	not available	not available
San Pedro, Ambergris Caye	2016/08/04 05:25UTC	52.7	97.6	60.6
Port of Belize	2016/08/04 05:56UTC	58.0	107.4	66.7
International Airport	2016/08/04 05:21UTC	44.4	82.2	51.1
Belmopan	2016/08/04 08:35UTC	38.0	70.4	43.7
Baldy Beacon, Mountain Pine Ridge	2016/08/04 09:55UTC	not available	not available	not available
Dangriga	2016/08/04 07:20UTC.	38.5	71.3	44.3
Placencia	2016/08/04 08:40UTC	24.0	44.4	27.6

As shown in Figure 4, the radar sequence from the Philip Goldson Airport shows the movement and qualitative rainfall intensity of Earl while approaching Belize. Radar images show reflectivity CAPPI (Constant Altitude Plan Position Indicator), which is a horizontal cross-section of data at constant altitude. For this set of data, the height is 2 km from the surface and the horizontal resolution is 1 km. Reflectivity values (dBZ) are correlated to rain rate (mm/h) by means of the empirical Marshall-Palmer relationship. Blue colours indicate weak to moderate rains, while green tones indicate moderate to intensive rains.

At 03UTC on 4 August (Figure 4, top left) westward rainbands affected Central and Northern Belize. Areas of moderate rain were very localized. At 04UTC (Figure 4, top right) more intense southern rainbands hit Central Belize, while, at 05UTC (Figure 4, bottom left), the western part of the hurricane extended over Belize completely. At 06UTC (Figure 4, bottom right) the centre of Earl made landfall near (10 km southwest of) Belize City.
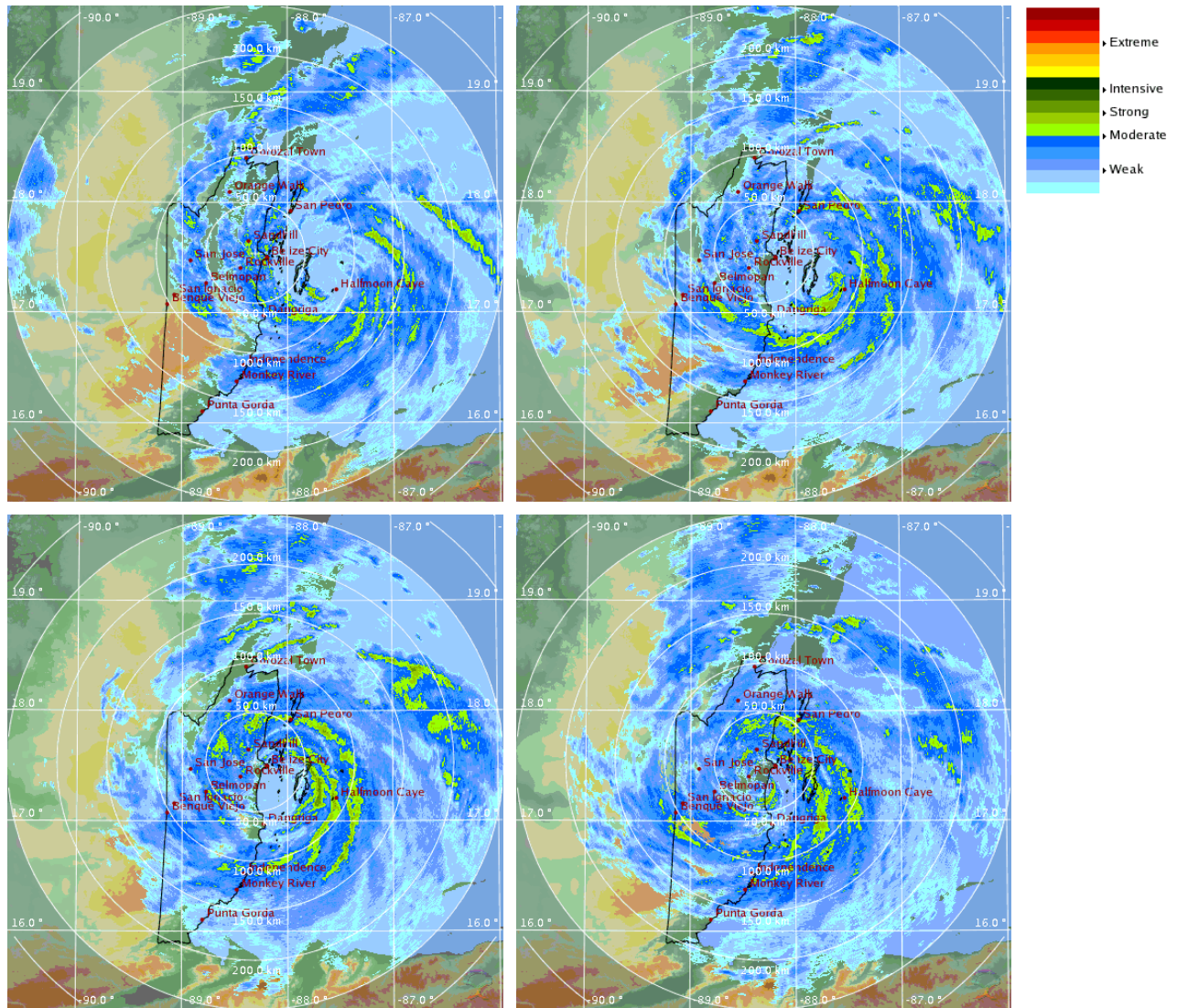
Figure 4 – Radar reflectivity CAPPI from Philip Goldson Airport (http://www.hydromet.gov.bz/images/stories/radar/) on 4 August at 03UTC (top left), at 04 UTC (top right), at 05UTC (bottom left) and 06 UTC (bottom right)

The sequence of radar acquisitions in Figure 5 displays the transition of the eye of Hurricane Earl over Belize. These images demonstrate that the stronger rainfall structures (in green) hit the central part of the country.
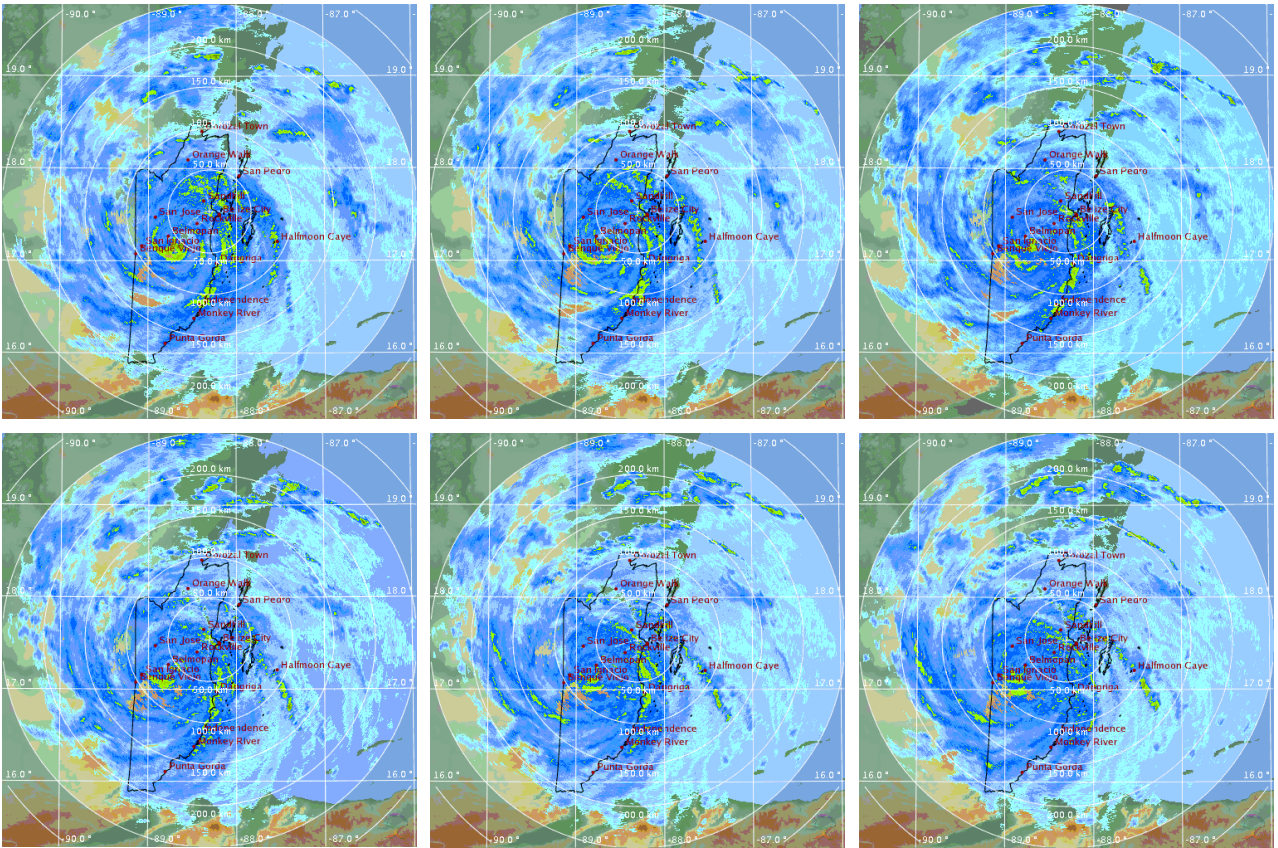
Figure 5 – Radar reflectivity CAPPI from Philip Goldson Airport (http://www.hydromet.gov.bz/images/stories/radar/) on 4 August from 07:15UTC to 08:45UTC. Time interval between radar acquisitions is 15 minutes

Radar images are not available from 0845UTC to 2112UTC, thus missing a great part of the hurricane event over Belize.

After 06UTC, in the hurricane's overland track towards the west-northwest, the hurricane central pressure increased and winds weakened (Figure 6).
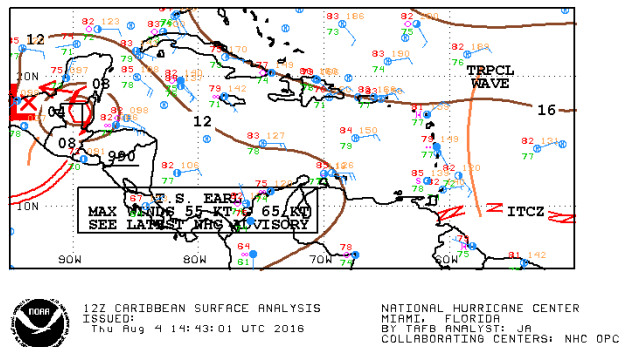

Figure 6 - National Hurricane Center surface analysis chart at 14UTC on 04/08/2016

3   IMPACTS

The National Emergency Management Organization (NEMO) issued several warnings and updates on the approaching hurricane, taking actions to prevent major damage caused by wind gusts or flash floods. The airport was closed and Civil Defence authorities opened 29 shelters. Preliminary estimates are that approximately 2,000 homes were damaged or destroyed, displacing many families. Inland and coastal flooding occurred in the central and northern cities and on the Cayes.

Additionally:
- The towns of Santa Elena and San Ignacio were covered with huge chunks of debris brought by the Macal River and some important avenues in the twin towns became rivers themselves. Savannah and Burns avenues in downtown San Ignacio were flooded, and many of the businesses in that area were flooded.
- Initial estimates by the Ministry of Agriculture were that the storm damaged almost 40,000 acres (~16,200 ha) in the Cayo district and almost 25,000 acres (10,100 ha) in the Orange Walk district.
- The Ministry of Tourism indicated that major tourist destinations sustained heavy damages, including San Pedro, Belize's top tourism destination and Caye Caulker.
- Water service on the mainland was lost in most areas directly hit by the storm, but was restored by late evening on 4 August. It took more time to restore potable water service in some coastal areas and islands.
- It is estimated that approximately 8,000 people have been assisted by Government of Belize.

The specialized digital service of the United Nations Office for the Coordination of Humanitarian Affairs, Reliefweb, issued a disaster alert for Belize and a report generated on 4 August indicated that:
- No deaths or major injuries occurred due to the passage of the Hurricane Earl.
- Approximately 10,000 people were affected; 119 people remained in shelters and others without electricity took shelter with relatives.
- Water levels had started to recede in flooded rivers in the Cayo District but flooding remained a concern in flood-prone areas, in Belize River Valley.
- The Belize City water supply was restored and water was being supplied in trucks to communities with interrupted public water supply.
- The Belize Electricity Company reported that 99% of the power was restored; the 1% without power was primarily in Belize City and affected rural areas in the Belize District.

The public media and information system was in full operation, with local and international reports broadcasting live reports and calls for help for those in danger by way of social media, radio and television.

The police, Belize Defence Force, medical and emergency organizations and other first responders also braved the storm and assisted as many people as they could reach. No loss of life has been reported as a direct result of the storm.

Figure 7- Damage in Belize, Belize City. Source: Channel 5 Belize & 7 News Belize

Figure 8- Damage in Belize. Regions of Ambergris Caye, Caye Caulker and San Ignacio. Source: San Pedro Scoop,

4   RAINFALL MODEL ANALYSIS

CAREs are monitored by three different datasets. The first one, CMORPH, is based on remotely sensed rainfall rates assessed on satellite retrievals, the other two are WRF model analyses obtained using two different cumulus schemes in the model configuration.

The CMORPH dataset identified the CARE associated with Hurricane Earl, but did not capture the high intensity precipitation, while both WRF configurations run in XSR 2.0 (the new Excess Rainfall model) captured the high intensity precipitation associated with the hurricane. The first WRF configuration (WRF1) better estimated the precipitation pattern.

Figure 9 shows the daily accumulated rainfall fields for 3, 4 and 5 August for the WRF1 configuration. On 4 August, higher rainfall values were simulated over Central Belize. On 5 August, moderate accumulated precipitation was estimated all along the eastern coast of the Yucatan Peninsula affecting Southern Belize in particular.
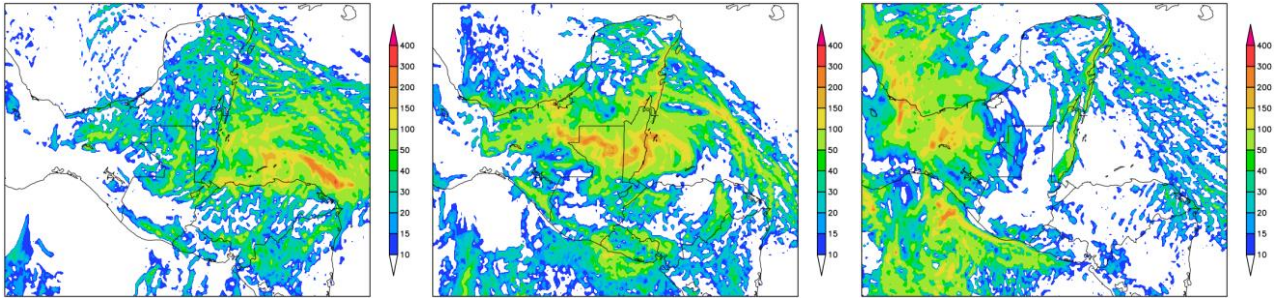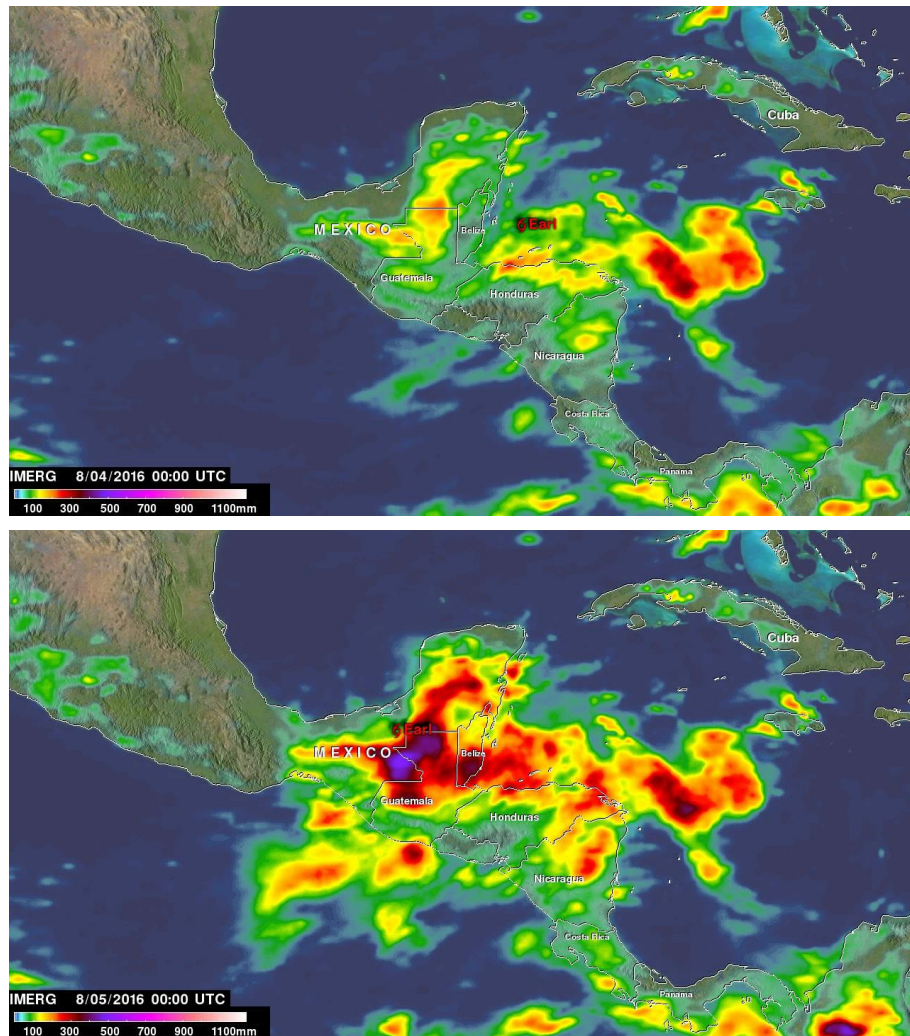
Figure 9 – Daily accumulated precipitation, in mm, for 3 August (left), 4 August (centre) and 5 August (right) for WRF1

These fields were comparable with those estimated from NASA's Integrated Multi-satellitE Retrievals for GPM (IMERG) for the event (Figure 10). Although the accumulation interval was different, areas of higher precipitation were well simulated.
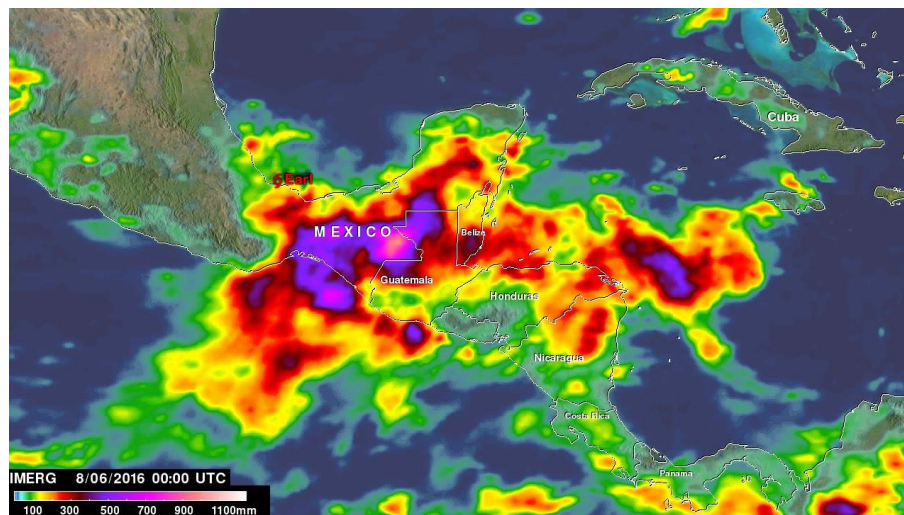
Figure 10 – Accumulated rain fields, in mm, for 3 August (top), 4 August (centre) and 5 August (bottom) from NASA's Integrated Multi-satellitE Retrievals for GPM (IMERG). The accumulation period started on 2 August (https://pmm.nasa.gov/extreme-weather/deadly-hurricane-earls-rainfall-measured-imerg).

5   TRIGGER POTENTIAL

The Rainfall Index Loss (RIL) calculated for this CARE was above the Attachment Point of Belize´s Excess Rainfall policy and therefore the policy was triggered and a payout of US$261,073 is due.

CCRIF reiterates our support to the Government and people of Belize and extends our wishes for a prompt recovery.

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.