Covered Area Rainfall Event
(6-7 September 2017)

Hurricane Irma
Excess Rainfall

Event Briefing
St. Kitts and Nevis

16 September 2017

1   INTRODUCTION

Irma, now recognized as the most powerful Atlantic Ocean hurricane in recorded history, formed as a tropical storm on 30 August at 15UTC, west of the Cape Verde Islands. It was upgraded to hurricane status on 31 August at 15UTC. Irma intensified moving across the Atlantic Ocean and reached the Leeward Islands as a major hurricane (category 5) on 6 September at approximately 12UTC. Heavy rain was experienced over the Leeward Islands, as well as hurricane-force winds (185 mph or 295 km/h) with higher gusts.

This report describes the results of the Excess Rainfall model (XSR 2.0) on CCRIF member country St. Kitts and Nevis. Other reports have been or will be issued regarding other CCRIF member countries that have Excess Rainfall policies.

St. Kitts and Nevis was affected by locally intense rainfall mainly between 2130UTC on 5 September and 1130UTC on 6 September 2017. The Rainfall Index Loss calculated for this Covered Area Rainfall Event (CARE) that started on 6 September and ended on 7 September 2017 was below the attachment point of St. Kitts and Nevis' Excess Rainfall policy and therefore no payout is due.

As reported in the previous Event Briefing on dated 8 September 2017 wind and storm surge effects from Tropical Cyclone Irma in the Leeward Islands, heavy rains and strong winds were experienced in St. Kitts and Nevis. The country's Tropical Cyclone policy which provides coverage for wind and storm surge, was triggered and a payout of US$2,294,603 was due under that policy.

2   EVENT DESCRIPTION

On 30 August 2017 at 15UTC, the US National Hurricane Center (NHC) reported that Tropical Storm Irma had developed west of the Cabo Verde Islands, with maximum sustained winds of 50 mph (85 km/h). During the following 24 hours, Irma moved toward the west at 13 mph (25 km/h) and it rapidly intensified due to the favourable thermodynamic environment: low wind shear, humid layers and the passage over warm water.
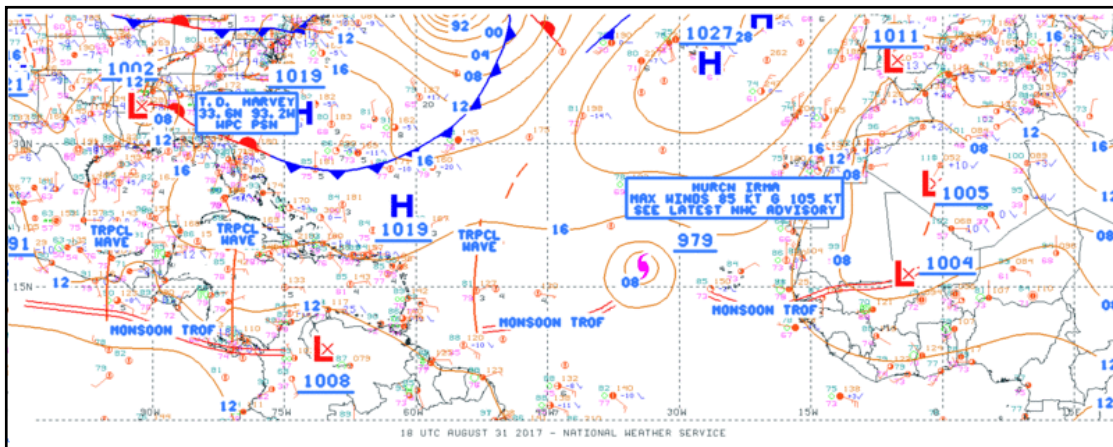

Figure 1 Surface analysis of the tropical Atlantic on 31 August at 18UTC.
Source: NOAA Ocean Prediction Center.

On 31 August at 15UTC, Irma was upgraded to a category 2 hurricane. At this time, Irma was located at 16.9N, 33.8W, featured maximum sustained winds of 100 mph (155 km/h) and the estimated minimum pressure was 979mb (Figure 1).
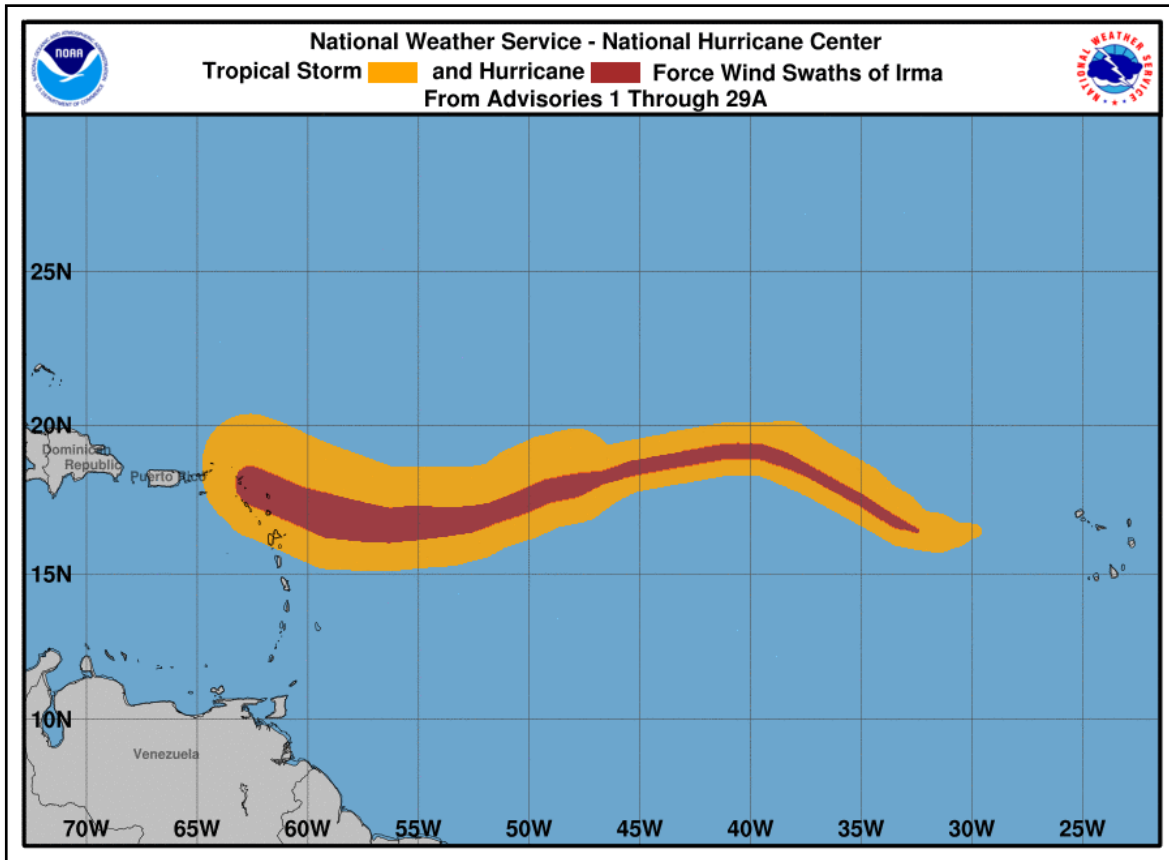

Figure 2 Irma's track and contouring of the wind speed intensity. Source: NHC

After 12 hours, Irma was further upgraded to a category 3 hurricane (thus becoming a major hurricane) since the observed maximum sustained winds were near 115 mph (185 km/h). During these hours, the hurricane moved in a west-northwest direction at 12 mph (19 km/h), to the south of the subtropical high pressure system extending over the central Atlantic and centred over the Azores (Figure 1).

Even though Irma was still embedded in a favourable low wind shear environment, its passage over colder surface water and its close proximity to the dry air of the high pressure system stopped Irma's rapid strengthening.

During the next few days, Irma continued to move along the southern border of the high pressure system. This condition made the hurricane track initially steer west- southwest (from 2 September at 15UTC to 4 September at 3UTC), then west (from 4 September at 3UTC to 5 September at 15UTC) and finally toward the west-northwest (from 5 September at 15UTC to 6 September at 12UTC) at a roughly constant forward velocity of about 13-15 mph (20-24 km/h) (Figure 2).
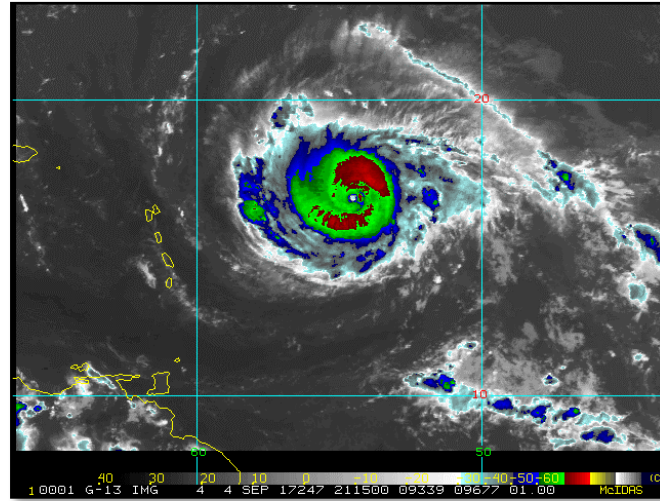
Figure 3 Enhanced infrared satellite image on 4 September at 2115UTC. Red and green indicate, respectively, very high and high top clouds. Source: NOAA

The hurricane-force winds remained constant until 4 September when further intensification took place. On 4 September at 21UTC, Irma became a category 4 hurricane, with maximum sustained winds of 140 mph (220 km/h) and minimum central pressure of 943 mb. At this time, the hurricane eye was located near 16.7N, 55.6W and the hurricane structure was well defined, showing a clear eye and a symmetrical cloud overcast ring around it, with very high top cloud (Figure 3).

On 5 September at 1500UTC, NHC further upgraded it to a category 5 hurricane, with maximum sustained winds of 180 mph (285 km/h). The estimated minimum central pressure was 931 mb. Hurricane-force winds extended outward up to 60 miles (95 km) from the centre and tropical-storm-force winds extended outward up to 160 miles (260 km).

A few hours later, Irma reached the western edge of the subtropical high pressure system, thus allowing it to gain latitude and its track turned towards the west-northwest, heading towards the northern Leeward Islands. The core passage over the northern Leeward Islands occurred on 6 September at about 06-12UTC. At this time, the maximum sustained winds were approximately 185 mph (295 km/h) with higher gusts and the estimated minimum central pressure was 914 mb.

Isolated rain showers associated with the outward rain bands of Irma first affected St. Kitts and Nevis on 5 September at 2130UTC (Figure 4a). On 6 September at 0630UTC, the heavy rain associated with the core of the hurricane reached St. Kitts and Nevis (Figure 4b). The southern sector of Irma's inner rain bands passed over Anguilla, yielding high rates of precipitation between 0630 UTC (Figure 4b) and 1130UTC (Figure 4c). At 1130UTC, the core of Irma left St. Kitts and Nevis (Figure 4c). Isolated rain showers associated with the outward rain bands of Irma intermittently affected the island from that time until 6 September at 22UTC (Figure 4d).

Antigua and Barbuda and Anguilla were among the CCRIF members within the Leeward Islands also affected by the heavy precipitation associated with the core of the hurricane.

During the following hours, the hurricane continued to move towards the west-northwest with a forward velocity of 16 mph (26 km/h) and unvaried wind intensity and minimum pressure. The British Virgin Islands, Puerto Rico, Dominican Republic, Haiti, the Turks and Caicos Islands and The Bahamas were also affected. Event Briefing Reports were prepared for the other CCRIF countries affected.
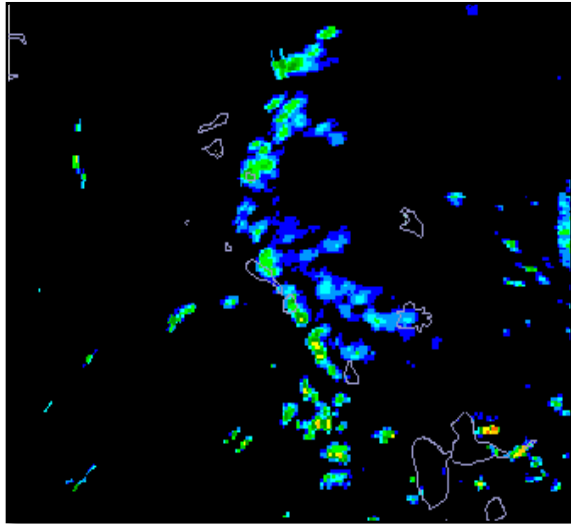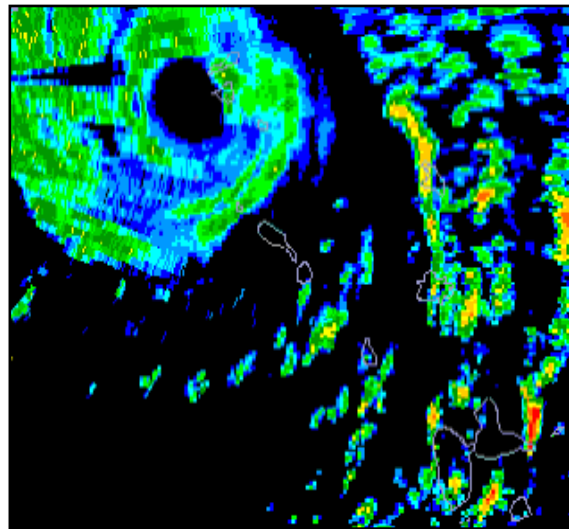

a) 5 September at 21:30 UTC
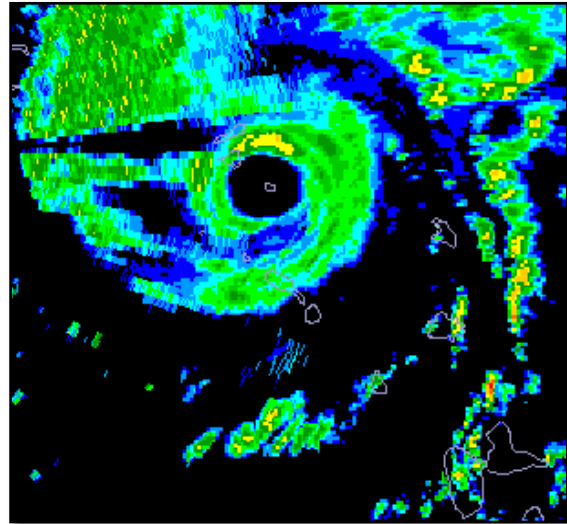
b) 6 September at 09:30 UTC
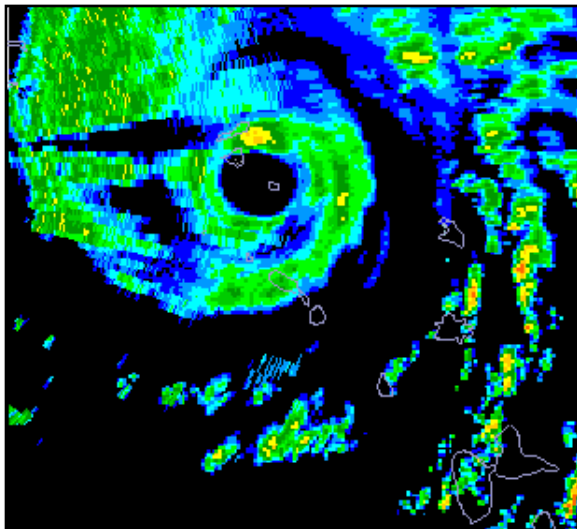
c) 6 September at 10:00 UTC

d) 6 September at 11:30 UTC

Figure 4 Reflectivity maps from the radar composite collected at different times
(source: *www.barbadosweather.org*)

3   IMPACTS

Nine days after Hurricane Irma affected St. Kitts and Nevis, Prime Minister Dr. Timothy Harris, reported that the passage of the hurricane through the country left significant damage to infrastructure, property as well as the interruption of electric power and the temporary closure of the airport.

As of the date of this report, Prime Minister Dr. Timothy Harris noted that these estimates reflect damage mostly in the public sector and they are still awaiting reports from the private sector. The estimates are only preliminary, as the work is still continuing.

The Nevis Disaster Management Department (NDMD) reported minimal damage such as: flooding of the airport, fallen trees, broken electricity lines and erosion of some of the coast on the southern, western and northern areas of Nevis.

4   RAINFALL MODEL OUTPUTS

The trajectories of the accumulated precipitation reported by CMORPH[1] and the two WRF[2] configurations on 6 September agreed with the trajectory inferred by the synoptic event description and from the radar reflectivity maps (Figure 4). Indeed, the system core (the ring of heavy convective precipitation surrounding the eye) moved toward the west north-west, passing over the northern Leeward Islands. Peak accumulated daily precipitation was greater than 200 mm on 6 September for both CMORPH and the two WRF configurations (Figure 5). However, the spatial pattern of accumulated precipitation differed in the following three configurations:

- CMORPH reported the highest accumulation (230 mm) on the waters between Barbuda and Anguilla.
- WRF1 simulated an extended and almost homogeneous area over which the daily accumulated precipitation was 340 mm, fully covering the waters between the British Virgin Islands and Antigua and Barbuda.
- WRF2 simulated the highest accumulation (328 mm) in a continuous line passing over the waters north of the Leeward Islands.

The difference between the two WRF configurations is explained by the fact that WRF1 represents the precipitation occurring in the hurricane core in a more symmetric way compared with WRF2.WRF2 showed the highest rainfall in the northern sector of Irma's core and in this sense, better captured the asymmetric pattern of precipitation as evidenced by the reflectivity radar maps (Figure 4), for which the highest rainfall rates often occurred in the northern sector of the core. These divergent patterns evidenced by WRF1 and WRF2 are caused by the use of two different schemes of convection in the two model configurations.

---

[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] WRF1 and WRF2 Models: the Weather Research and Forecasting Model [*https://www.mmm.ucar.edu/weather-research-and-forecasting-model*] weather model-based Configuration #1 and #2 data. These data is 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.
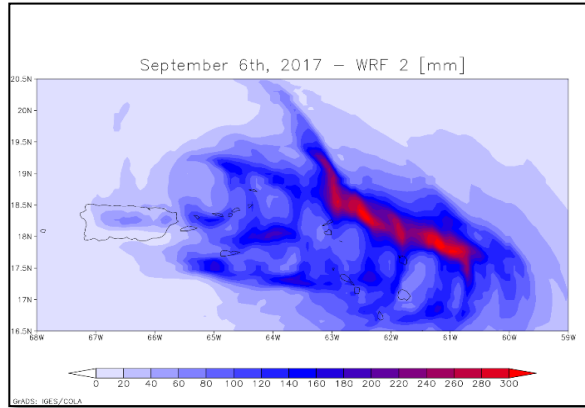
a) CMORPH
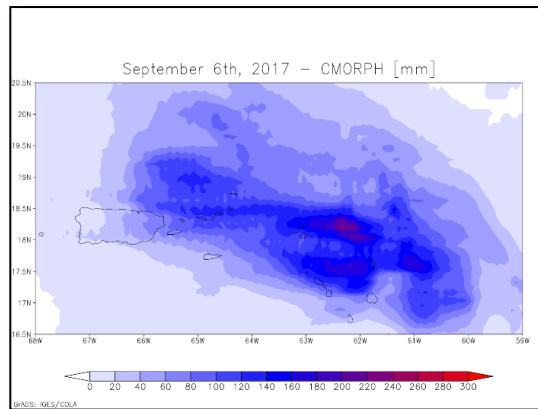
b) WRF1
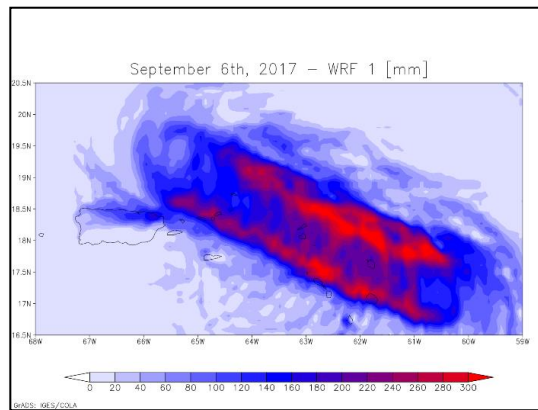
c) WRF2

Figure 5 Rainfall accumulated precipitation at 8km resolution on 6 September 2017. Source: XSR Web.

The different spatial distribution of precipitation led to different daily accumulated precipitation over St. Kitts and Nevis. CMORPH estimated an accumulated precipitation ranging between 60 and 130 mm, while WRF1 simulated a range between 50 and 245 mm, and WRF2 between 90 and 135 mm (Figure 6).
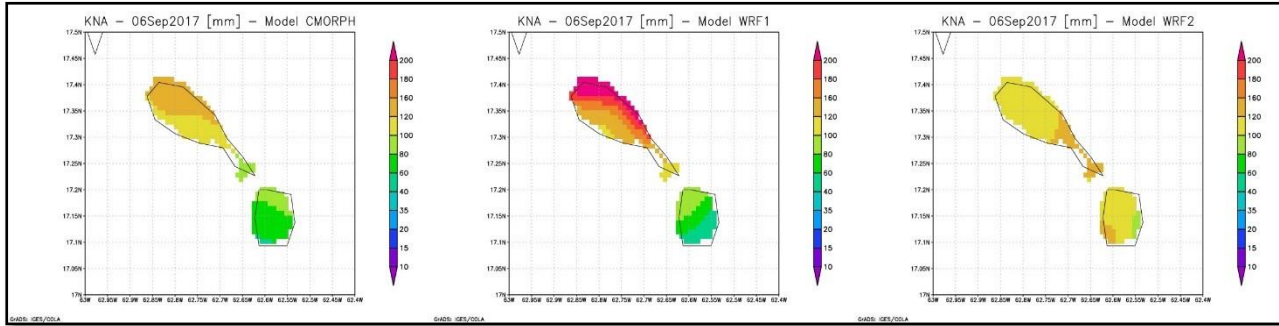
Figure 6 Accumulated precipitation (rainfall) at 1km resolution on 6 September 2017 CMORPH (left), WRF1 (middle) and WRF2 (right). Source: XSR Web

No surface measurements of precipitation were available to us for the hours when the hurricane passed over St Kitts and Nevis. NHC forecasted an accumulated precipitation of 8 to 12 inches (200-300 mm), with isolated areas of 20 inches (500 mm) over the Northern Leeward Islands associated with Irma's passage. In this respect, the precipitation accumulation simulated by WRF1 was closer to the NHC estimate.

a)   b)
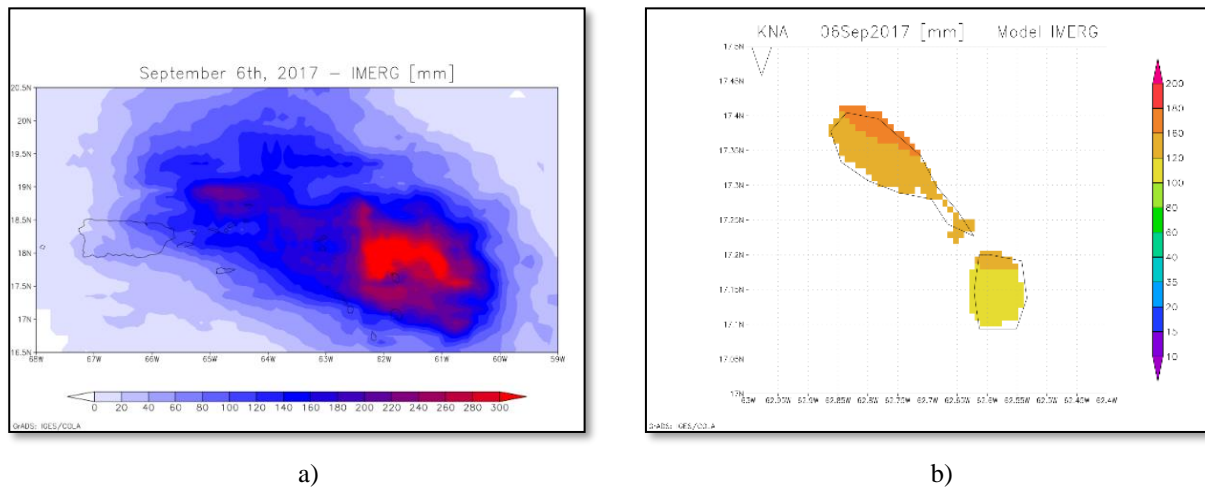
Figure 7 IMERG accumulated precipitation (rainfall) at 10km (a) and 1km (b) resolutions on 6 September 2017.

Additional satellite precipitation estimates are available through the IMERG (Integrated Multi-satellitE Retrievals for GPM) dataset (Figure 7), which estimated precipitation patterns and values in good agreement with those simulated by CMORPH, WRF1 and WRF2. The peak of accumulated daily precipitation is about 380 mm, located over the ocean to the northwest of Barbuda.

Over St. Kitts and Nevis, IMERG estimated precipitation values ranging between 100 and 160 mm. Compared to these values, CMORPH slightly underestimated the precipitation over both islands, while WRF1 simulated higher precipitation in St. Kitts and lower values in Nevis. WRF2 was in good agreement with IMERG over Nevis, while simulated lower values in St. Kitts. Given the different behaviour of the 3 datasets, the final estimate derived by their average well represented the precipitation observed by IMERG.

5   TRIGGER POTENTIAL

The Rainfall Index Loss was calculated for this Covered Area Rainfall Event (CARE) that started on 6 September and ended on 7 September 2017, was below the attachment point of St. Kitts and Nevis' Excess Rainfall policy and therefore no payout is due.

CCRIF expresses sympathy with the Government and people of St. Kitts and Nevis for the impacts on communities and infrastructure caused by this event.

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

Evaluación de Riesgos Naturales
Vito Alessio Robles No.179
Col. Hda. Gpe. Chimalistac.
Del. Álvaro Obregón. CP 01050, México D.F.
+52 (55) 5616-8161, 62, 64
cavelar@ccrif.org

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 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 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.
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 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, 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.