



Covered Area Rainfall Event (5-8 October 2017)

Tropical Storm Nate Excess Rainfall

Event Briefing

Nicaragua

16 October 2017

1 INTRODUCTION

Nate is the sixteenth tropical cyclone of the 2017 Atlantic Hurricane Season. It formed as a tropical depression in the southwestern Caribbean Sea on 4 October at 1500UTC and it became a tropical storm on 5 October at 1200UTC before making landfall on the Nicaragua coast. Its core passed over eastern Nicaragua with tropical-storm-force winds over the Atlantic coastal area. Heavy rainfall was experienced over the coastal waters of Nicaragua, as well as tropical-storm-force winds with higher gusts.

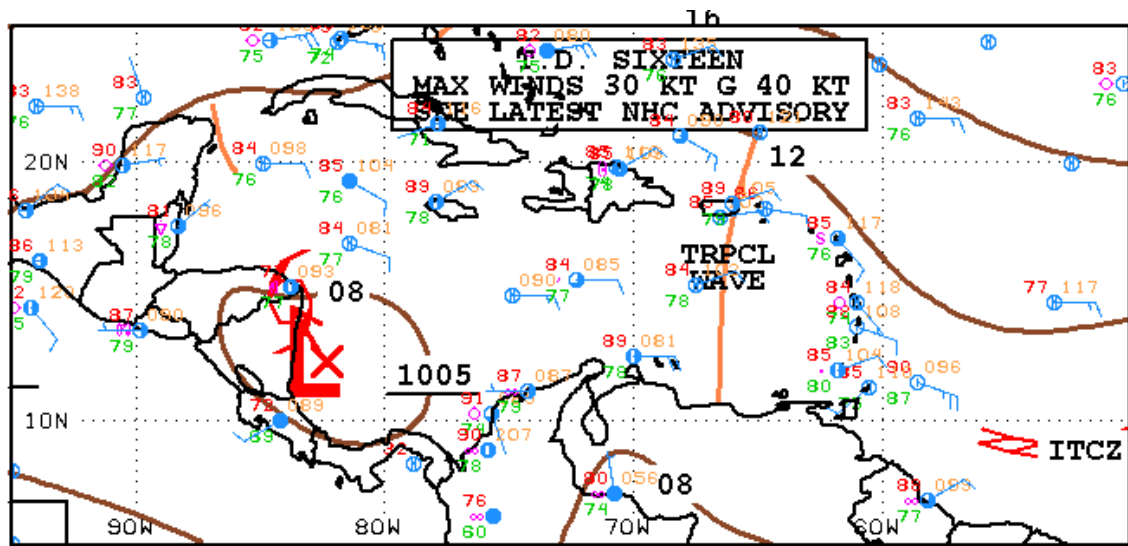
This report describes the results of the Excess Rainfall model (XSR 2.0) on CCRIF member country Nicaragua, for the rains associated with Tropical Storm Nate.

Nicaragua was affected by heavy precipitation between 1200UTC and 2100UTC on 5 October. The Rainfall Index Loss, calculated for this Covered Area Rainfall Event (CARE) that started on 5 October and ended on 8 October 2017, was below the attachment point of Nicaragua's Excess Rainfall policy and therefore no payout is due.

As reported in the previous Event Briefing dated 8 October 2017 for Tropical Cyclone Nate that affected Nicaragua's coast, the preliminary runs of CCRIF's loss model for wind and storm surge produced government losses for Nicaragua. However, Nicaragua's Tropical Cyclone policy, which provides coverage for wind and storm surge, was not triggered because the modelled losses were below the policy's attachment point.

2 EVENT DESCRIPTION

On 4 October 2017 at 1500UTC, the US National Hurricane Center (NHC) reported that a low pressure system located in the southwestern Caribbean Sea became organized, becoming a tropical depression, the sixteen tropical cyclone of the 2017 Atlantic Hurricane Season. The depression was centered near 12.2N 81.9W, off the coast of Nicaragua, and was moving toward the northwest with an estimated minimum central pressure of 1005 mb (Figure 1).

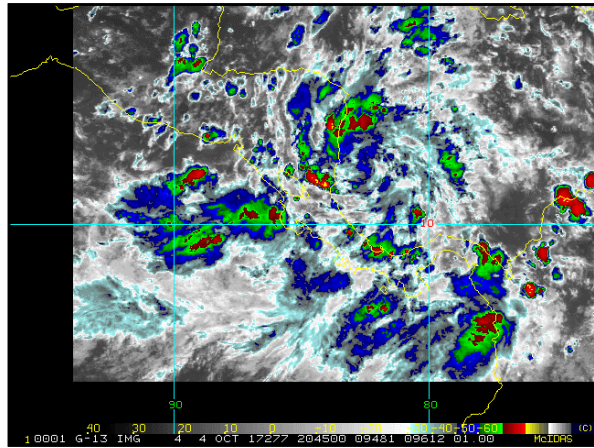


18Z CARIBBEAN SURFACE ANALYSIS
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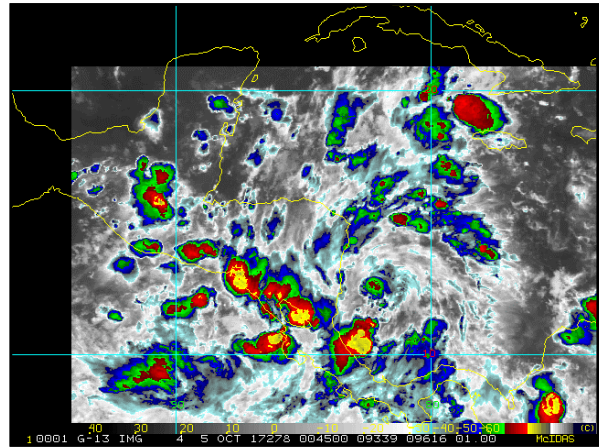
NATIONAL HURRICANE CENTER
MIAMI, FLORIDA
BY TAFB ANALYST: MH/MRF
COLLABORATING CENTERS: NHC OPC

Figure 1 Surface analysis of the tropical Atlantic Ocean on 4 October at 1800UTC.
Source: NOAA Ocean Prediction Center.

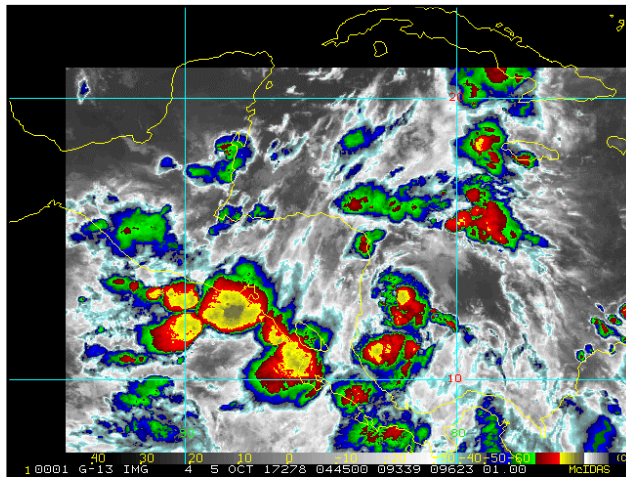
Starting on 4 October at 2030 UTC, some scattered moderate and isolated strong convection associated with the tropical depression occurred in inland Nicaragua, as evidenced by the high cloud canopy visible in the satellite imagery shown in Figure 2. These deep convection cells were indications of thunderstorms and showers. The convection cells were originally located along the outer rain bands of tropical depression 16 and affected eastern Nicaragua (Figure 2a, at 2045UTC). In the next few hours, the thunderstorms intensified (as identified by the higher and wider canopy top) and moved toward the west, remaining over the western portion of Nicaragua (see the squall line in Figure 2b, at 0045UTC) and on the waters off the Pacific coast (Figure 2c, on 5 October at 0445UTC). The heavy rainfall associated with this squall line affected the country until 5 October at approximately 1800UTC. However, scattered moderate convection was still experienced until 6 October at 0400UTC.



a) 4 October at 2045UTC



b) 5 October at 0045UTC



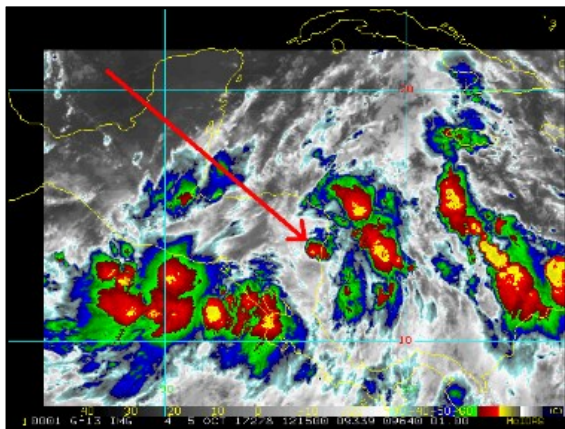
c) 5 October at 0445UTC

Figure 2 Enhanced infrared imagery over the western Caribbean Sea, collected at different times. Colours indicate the cloud canopy temperature, with yellow to red indicating the colder (higher) canopy and green to blue the warmer (lower) canopy. Source: NOAA, National Environmental Satellite, Data and Information Service

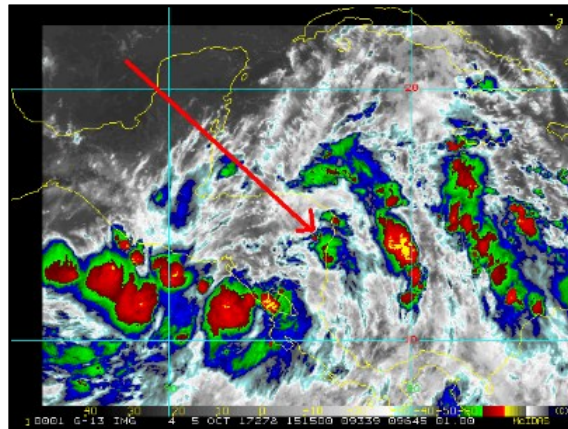
On 5 October 2017 at 1200UTC, tropical depression 16 became a tropical storm. The conducive conditions for its intensification (low shear and passage over warm and deep waters in the southwestern Caribbean Sea) led to a rapid transition from a tropical depression to a tropical storm. The storm was named Nate and, at the time of being upgraded, its centre was located 15 km off the Atlantic coast of Nicaragua, at 13.9N, 83.4W (Figure 1). The storm moved slowly (8 mph, 13 km/h) towards the northwest, towards inland Nicaragua. The estimated minimum central pressure was 999 mb. Maximum sustained winds were near 40 mph (65 km/h) with higher gusts and tropical-storm-force winds extended outward to 60 miles (95 km), mainly over water to the east of the storm centre. The organized cloud pattern associated with the tropical storm indicated the development of a ragged central convective feature and outer banding in the northeastern semicircle (Figure 3).

During the next 9 hours, the centre of Nate traversed Nicaragua, passing over the northeastern portion of the country. Due to the interaction with land, the cloud pattern associated with the storm lost its organization (Figure 3), which indicated that the storm did not intensify further. Within this period, the storm continued to move in a northwesterly direction with a forward speed of 9 mph (15 km/h) and the minimum pressure remained at 999 mb. The maximum sustained winds remained near 40 mph (65 km/h) and an area extending a further 50-70 miles (85-110 km) was affected by tropical-storm-force winds. However, on the basis of ASCAT satellite information, NHC suggested that there were no tropical-storm-force winds outside of the coastal waters of Nicaragua.

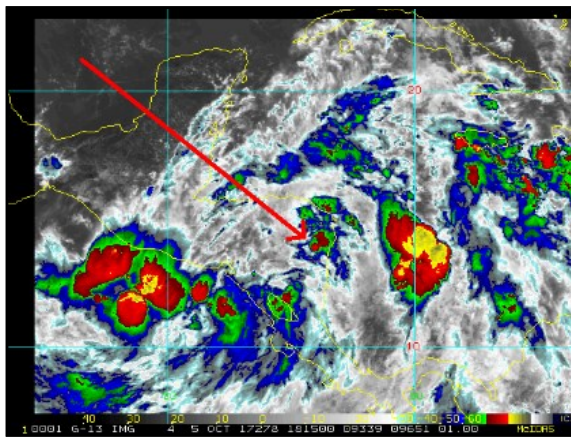
Moreover, Figure 3 indicates that a relatively weak convection system was associated with the core of the storm when passing over Nicaragua, compared to the one related to the thunderstorms on the Pacific coast of the country. Indeed the largest precipitation over Nicaragua associated with Nate occurred in the western portion of the country, and not in the direct path of the storm.



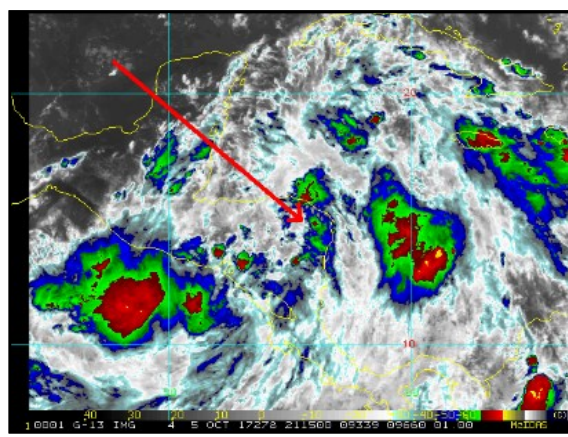
a) 5 October at 1215UTC



b) 5 October at 1515UTC



c) 5 October at 1815UTC



d) 5 October at 2115UTC

Figure 3 Enhanced infrared imagery over the western Caribbean Sea, collected at different times. The red arrow indicates the approximate location of Tropical Storm Nate. Colours indicate the cloud canopy temperature, with yellow to red indicating the colder canopy and green to blue the warmer canopy. A cold cloud canopy indicates deep convection. Source: NOAA, National Environmental Satellite, Data and Information Service.

On 5 October at 2100UTC, Nate left inland Nicaragua, moving into eastern Honduras. During the following hours, Nate left Honduras and moved over the warm waters of the northwestern Caribbean Sea, passing through the Yucatan Channel and over the waters of the Gulf of Mexico. The favourable environment for storm intensification led Nate to become a category 2 hurricane before making landfall close to the mouth of the Mississippi River in the United States. Finally, the interaction with land rapidly weakened the hurricane, which dissipated over the southeastern United States (Figure 4).

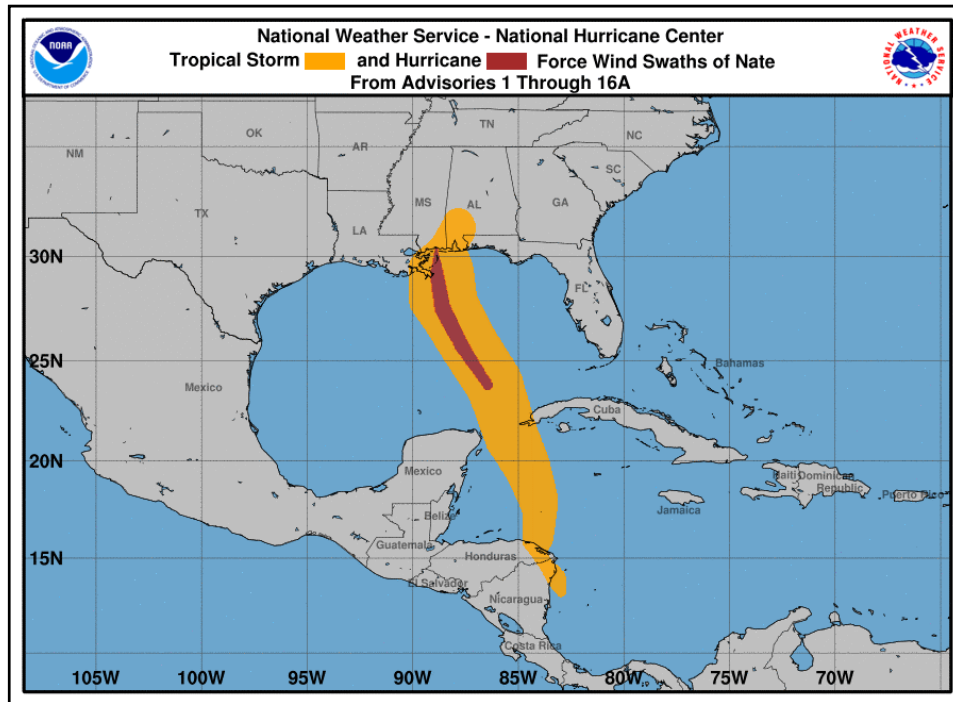


Figure 4 Nate's track and contouring of the wind speed intensity. Source: NHC

3 IMPACTS

According to VicePresident Rosario Murillo, based on a National Consolidated Summary report of Nicaragua's Disaster Management Agency (SINAPRED), there were 15 confirmed deaths and 1 person missing. Also, 32,684 people were affected by floods, mudslides, destroyed roads and damaged houses. Several areas were left without electricity. As of the date of this report impacts were:

- 87 affected municipalities
- 120.15 km of bridges, highways, roads and sewer systems affected
- 7,840 families and 5,900 homes affected

Prior to the arrival of Tropical Storm Nate, Nicaragua's authorities took precautionary measures, including evacuating 729 people, closing all schools and opening shelters. The Nicaraguan Red Cross' Emergency Operations Centre and its local branches were activated.

Figure 5 shows the flood damage caused by Tropical Storm Nate in Nicaragua.



Figure 5 Damage caused by Tropical Storm Nate in Nicaragua – October 2017.
Sources: *El Nuevo Diario* and *El 19 Digital*

4 RAINFALL MODEL OUTPUTS

The general spatial pattern of the accumulated precipitation reported by CMORPH¹ and the two WRF² configurations on 4-8 October agree with the distribution inferred by the synoptic event description (Figure 2 and Figure 3). Indeed, the largest amounts of accumulated precipitation were simulated in all cases in the western sector of Nicaragua and on the Pacific and Atlantic waters. The peaks of accumulated precipitation on 4-8 October were registered on the Pacific waters in all three cases, but their values differed widely, with WRF1 producing much larger values than CMORPH and WRF2 (CMORPH: 414 mm; WRF1: 954 mm; WRF2 496 mm).

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/emorph_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.

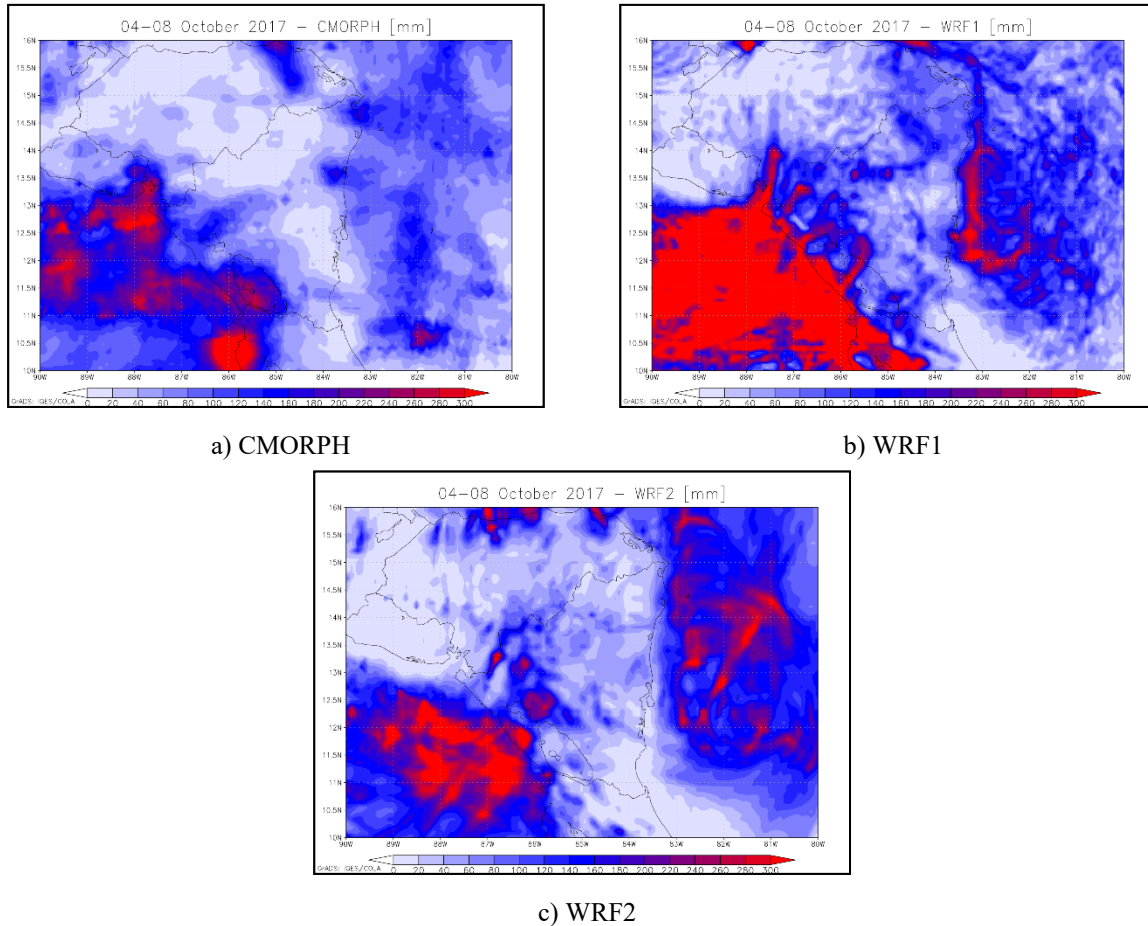


Figure 6 Rainfall accumulated precipitation at 8km resolution during 4-8 October 2017. Source: XSR Web

A detailed analysis of the simulation of the inland (daily accumulated) precipitation is reported only for 4 to 6 October (Figure 7), when the precipitation associated with TC Nate occurred.

- On 4 October, CMORPH showed moderate precipitation occurring over western Nicaragua and on the northeastern coast, close to the simulated tropical storm inland point. WRF1 located the rainfall in the centre of the country, with a peak on the southeast coast to the north of Bluefields, while WRF2 presented weak precipitation to the northwest of South Caribbean Coast Autonomous Region.
- On 5 October, CMORPH reported high to very high precipitation in western Nicaragua (with a peak greater than 200 mm/day in the south) and in the northwestern sector, coherent with the passage of the tropical storm in the area. WRF1 was coherent in estimating the amount of rainfall but simulated a larger area directly affected by the passage of the storm in the north and no rainfall in the northwest region. WRF2 again presented smaller accumulated rainfall values compared with the other simulations, both in terms of amount and spatial extent.
- On 6 October, CMORPH reported moderate to high precipitation in northwestern Nicaragua. Both WRF configurations showed greater rainfall in terms of amount and spatial extent.

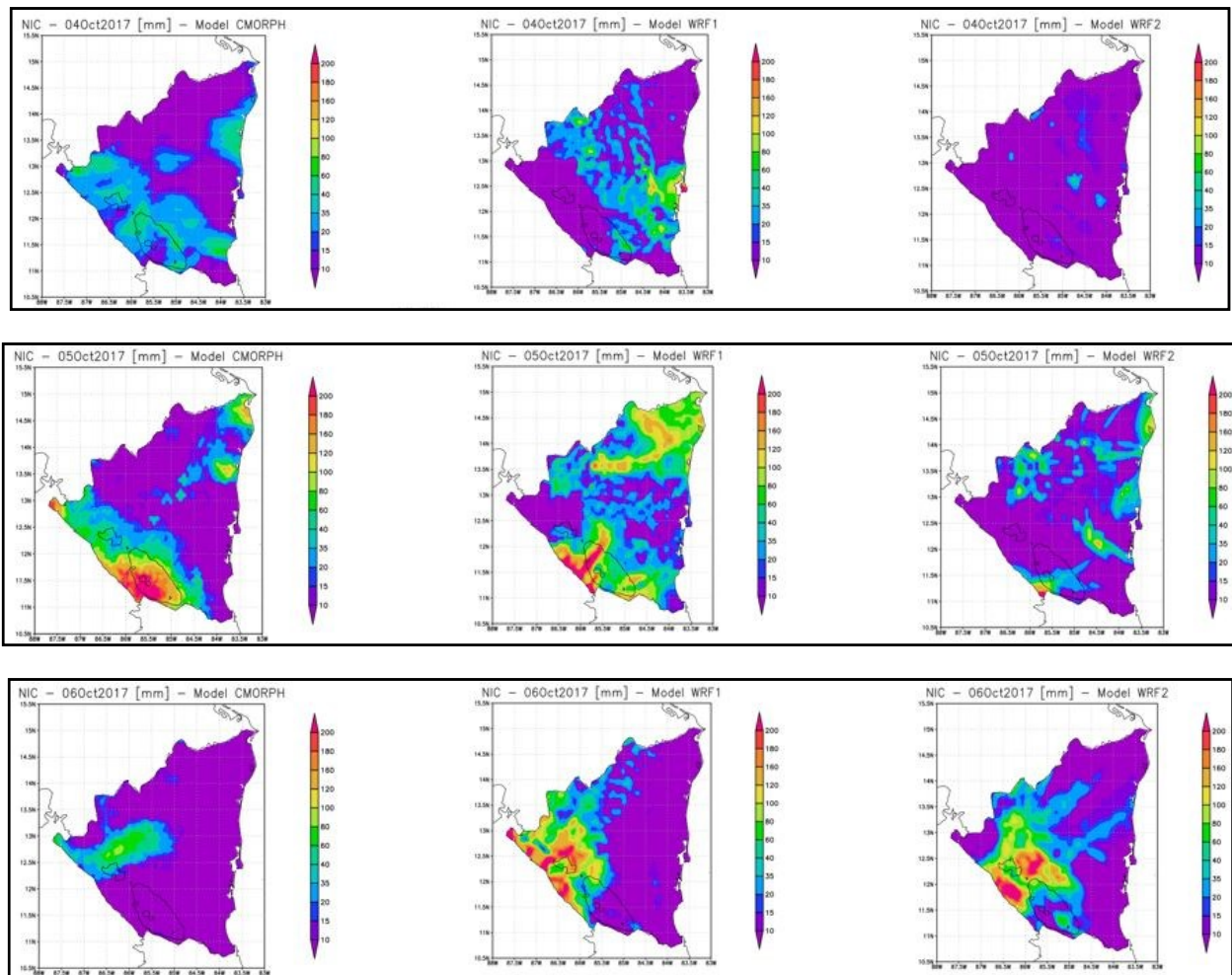


Figure 7 Accumulated precipitation (rainfall) at 1km resolution on 4 (top), 5 (middle) and 6 (bottom) October 2017 CMORPH (left), WRF1 (middle) and WRF2 (right). Source: XSR Web.

None of the rain gauges located in Nicaragua available to us (source: <https://www.ncdc.noaa.gov>) were active during the full event (from 4 to 6 October). Therefore, it is not possible to formulate a fair comparison with the modelled precipitations.

Satellite precipitation estimates are available through the IMERG (Integrated Multi-satellitE Retrievals for GPM) dataset (Figure 8), which estimated precipitation patterns in general agreement with those simulated by CMORPH, WRF1 and WRF2. Indeed, in all cases, the largest precipitation occurred over the Pacific and Atlantic waters of Nicaragua and inland on the western portion of the country. With regard to the daily accumulated precipitation, the agreement between IMERG and CMORPH was particularly high, both in terms of spatial distribution and accumulated amount (only on 6 October, IMERG reported slightly higher values compared to CMORPH). With respect to IMERG, WRF1 overestimated the accumulated rainfall for all three days, and located the precipitation pattern in the same regions on 5 and 6 October and in different regions on 4 October. WRF2 presented a different rainfall pattern compared with IMERG, and additionally it underestimated the accumulated rainfall on 4 and 5 October while overestimated it on 6 October.

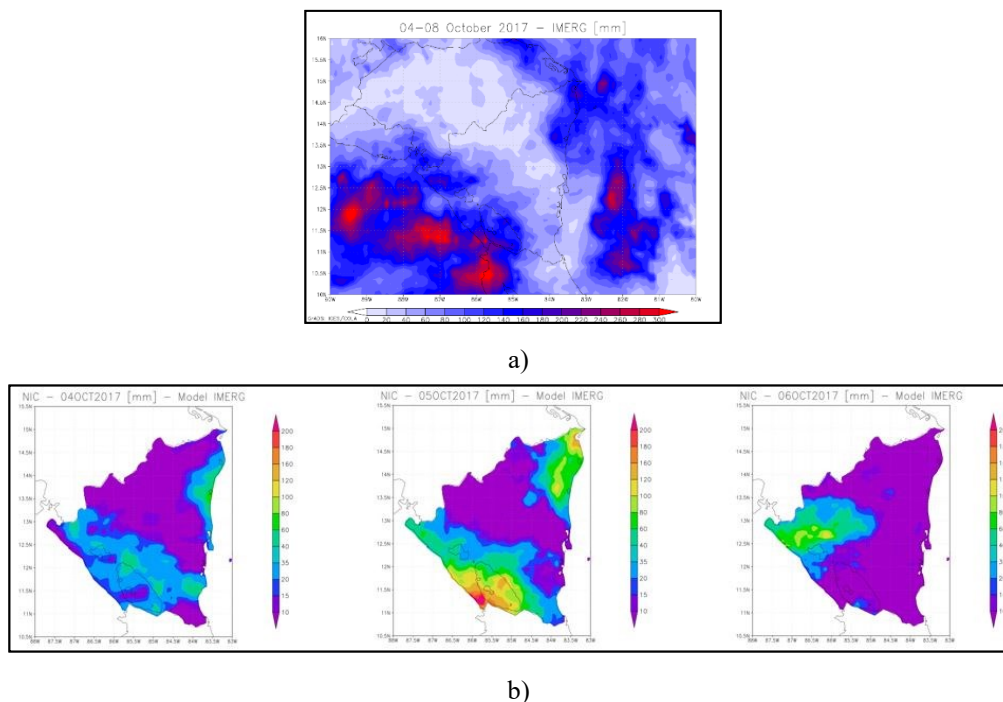


Figure 8 IMERG accumulated precipitation (rainfall) at 10 km (a) and 1 km (b) resolutions on 4-6 October 2017
Source: XSR Web.

The largest Rainfall Index Loss (RIL) was produced by WRF1 ($RIL_{WRF1} = US\$15,999,126.48$), due to the largest amount and extension of rainfall compared with that from both CMORPH and WRF2 during the event. WRF2 also produced an RIL larger than the Country Loss Threshold ($RIL_{WRF2} = US\$10,377,375.20$), but smaller than that from WRF1. Finally, the RIL from CMORPH (RIL_{CMORPH}) was much lower than the Country Loss Threshold. This likely occurred because CMORPH located the highest precipitation in low exposure regions. Therefore, since a Disaster Alert was issued, the final RIL for this event was equal to the average of the RIL_{WRF1} and RIL_{WRF2} ($RIL = US\$13,188,250.85$).

5 TRIGGER POTENTIAL

The Rainfall Index Loss, calculated for this Covered Area Rainfall Event (CARE) that started on 5 October and ended on 8 October 2017, was below the attachment point of Nicaragua's Excess Rainfall policy and therefore no payout is due.

CCRIF expresses empathy with the Government and people of Nicaragua for the loss of life and 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

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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 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 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.