# Using GOES-16 to Provide Critical Decision Support Services in the Wake of Major Hurricane Maria


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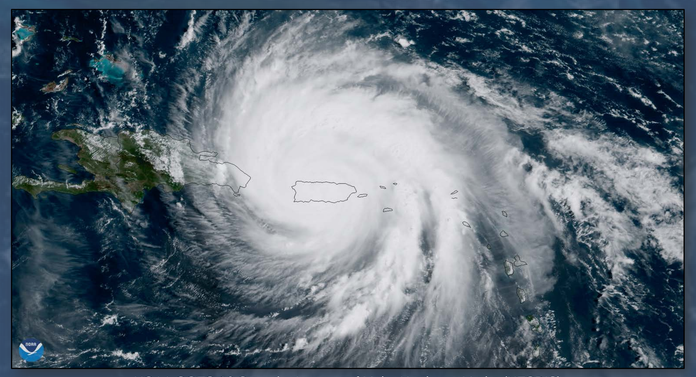
## Introduction

Hurricane Maria caused catastrophic damage to Puerto Rico and the U.S. Virgin Islands just two weeks after Hurricane Irma devastated much of the northeast Caribbean. Upon Maria's landfall on the southeast side of Puerto Rico, the Doppler Radar was completely destroyed and went offline indefinitely. Strong winds also took down the local NWS office's communication lines, in addition to the majority of the island's automated surface observations. In order to continue the NWS's mission of protecting life and property, several forecasters were deployed to NWS Miami to perform complete backup operations for NWS San Juan. The new GOES-16 satellite provided critical information for decision support services, as well as convective warning operations with improved temporal and spatial resolution, while radar imagery was not available. The data were essential for predicting strong convection in real-time, using several of the Advanced Baseline Imager (ABI) bands.

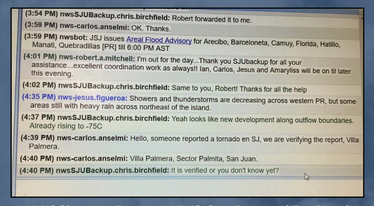


NOAA GOES-16 Geocolor Imagery of Major Hurricane Maria (NESDIS)

## Communications

The collapse of the power grids in both Puerto Rico and the U.S. Virgin Islands cut nearly all power and communication.

- AWIPS software at NWS San Juan continued to import satellite and model data, but dissemination of critical warning products ceased.
- NWSChat, satellite phones, and the Hurricane Hotline became a means to keep comms open between Puerto Rico and the National Weather Service.
- Open comms worked but weren't always reliable.
- Through NWSChat, we were notified of a possible tornado touching down in San Juan, PR, as well as a bridge collapse due to landslides in Utuado, PR, cutting off the town of Utuado.



(3:54 PM) **nwsSJUBackup.chris.birchfield:** Robert forwarded it to me.
(3:59 PM) **nws-carlos.anselmi:** OK. Thanks.
(3:59 PM) **nwsbot:** JSJ issues Areal Flood Advisory for Arecibo, Barceloneta, Camuy, Florida, Hatillo, Manati, Quebradillas [PR] till 6:00 PM AST
(4:01 PM) **nws-robert.a.mitchell:** I'm out for the day...Thank you SJUbackup for all your assistance...excellent coordination work as always!! Ian, Carlos, Jesus and Amarylisss will be on til later this evening.
(4:02 PM) **nwsSJUBackup.chris.birchfield:** Same to you, Robert! Thanks for all the help
(4:35 PM) **nws-jesus.figueroa:** Showers and thunderstorms are decreasing across western PR, but some areas still with heavy rain across northeast of the island.
(4:37 PM) **nwsSJUBackup.chris.birchfield:** Yeah looks like new development along outflow boundaries. Already rising to -75C
(4:39 PM) **nws-carlos.anselmi:** Hello, someone reported a tornado en SJ, we are verifying the report, Villa Palmera.
(4:40 PM) **nws-carlos.anselmi:** Villa Palmera, Sector Palmita, San Juan.
(4:40 PM) **nwsSJUBackup.chris.birchfield:** It is verified or you don't know yet?

NWSChat Log Between NWS San Juan and Deployed Forecasters

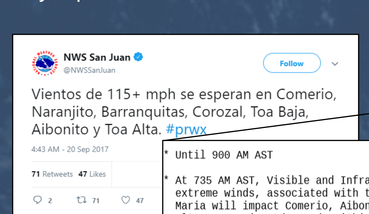
Collapsed Bridge in Utado (Eliud Echevarria, FEMA)

## Radar / Satellite

The destruction of the WSR-88D in Cayey, Puerto Rico ended radar coverage for Puerto Rico and the U.S. Virgin Islands at 0950Z on 20 September 2017. Continued weather coverage quickly relied heavily on new GOES-16 products as Maria's eyewall initially made landfall.

- Extreme Wind Warning issued immediately using scans from new GOES-16.
- Special Weather Statements, Flash Flood Warnings and Advisories all used a combination of 1-minute GOES-16 cloud top temperature scans along with 1-to-5 minute lightning data for weeks after the storm.
- GOES-16 ingest issues on 30 September 2017 led to the loss of coverage over PR and USVI. Was dependent on 15-min scans from GOES-13 at the start of heavy rain period.
- It would take 9 months to fully replace the WSR-88D. The radar came back online as of 22 June 2018.

Extreme Wind Warning at Landfall (Iowa Environmental Mesonet)



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* Until 900 AM AST

* At 735 AM AST, Visible and Infrared satellite imagery indicated
extreme winds, associated with the eyewall of Major Hurricane
Maria will impact Comerio, Aibonito, Barranquitas, Naranjito, Toa
Alta, Toa Baja and Dorado within the next hour. This is an
extremely dangerous and life-threatening situation!
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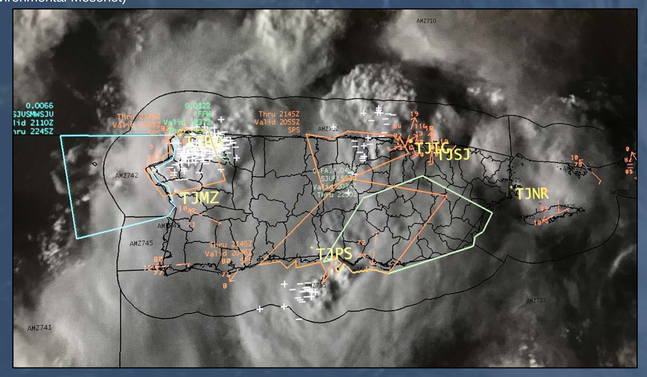
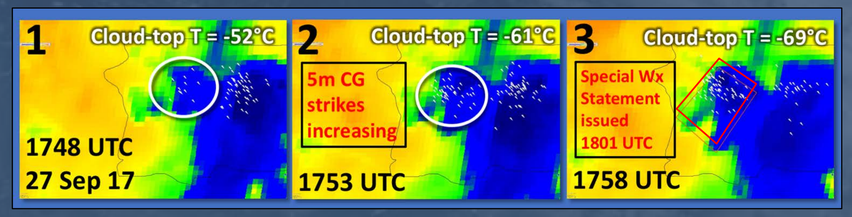
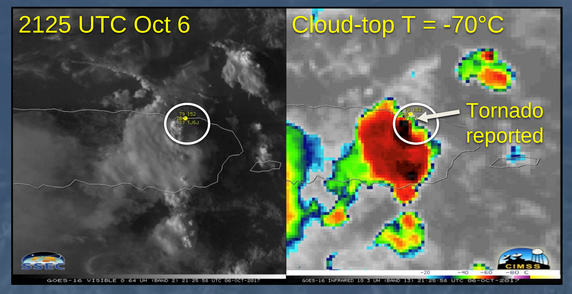



Special Weather Statements, Flood Advisories, Special Marine Warnings overlayed with Visible Satellite




ABOVE: Progression of developing convection leading to SPS issuance using IR satellite of cooling cloud tops and increase in lightning data.

LEFT: Despite satellite and lightning data aiding to issue advisories and warnings, tornado formation is impossible to detect using satellite alone, therefore this reported tornado was a missed event. Tornado development is seen in the extreme low levels, and is only captured with radar imagery.

## Decision Support Services

Supported recovery efforts due to hazardous weather and structural conditions for workers, especially those not from the area.

- Propane explosion in Corozal in the late evening. EM partners requested Hysplit trajectory model.
- Forecasted heavy rains would further deteriorate Guajataca Dam spillway (In the mountainous region of NW Puerto Rico) which was already structurally damaged by Maria.
- Landslide potential across the island was exacerbated by additional rainfall over saturated soils, especially in the mountainous region.
- Dangerous Heat Indices ranged in upper 90s to near 105°F daily.
- NWS San Juan continued to perform on-site DSS.

Guajataca Dam with compromised spillway.

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...REMARKS...
This is going to be transmitted via text to a satellite phone on PR.
Images, photos, docs, etc won&#39;t deliver over Satellite phone. Our
interest lies in any exposure to personnel as they work on Forest
Recovery that could worsen existing hazards such as weak trees, loose
soil, roadbeds etc. The focus is on the timing and amount and
duration of rain. This request is for Luquillo, PR. Another one will
be generated for Rio Grande, PR shortly. Please email me the
completed forecast as text to _____. Call with
questions._____. Thanks.
```

RIGHT: Remarks about use of satellite phone to disseminate a spot forecast. Workers would gather in the morning to hear expected conditions then disperse into areas where communication was minimal.

## Lessons Learned

Operations continued with the aid of GOES-16, especially with new 1-min meso-sector scans.

- Meso-sector scans are extremely useful, but cannot replace capabilities of radar. Radar gives finer details in the lower levels, where most weather occurs, that are not captured using satellite imagery alone.
- When performing backup duties of a downed WFO, changing NWSChat handle-names clears confusion (even within NWS itself) on who is actually backing up the office, e.g., nwsSJUBackup-forecaster.name
- AWIPS archiving of backup offices would aid in future research of large-scale events.
- Creating a binder of detailed "lessons learned" helped incoming temporary assignments new to the area to quickly spin up at the WFO.

WSR-88D TJUA destroyed (NWS San Juan)

New WSR-88D TJUA (Chris Birchfield)

## Acknowledgements


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- NOAA/NWS San Juan, PR
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- Cooperative Institute for Meteorological Satellite Studies (CIMSS)
- Iowa Environmental Mesonet, Iowa State University