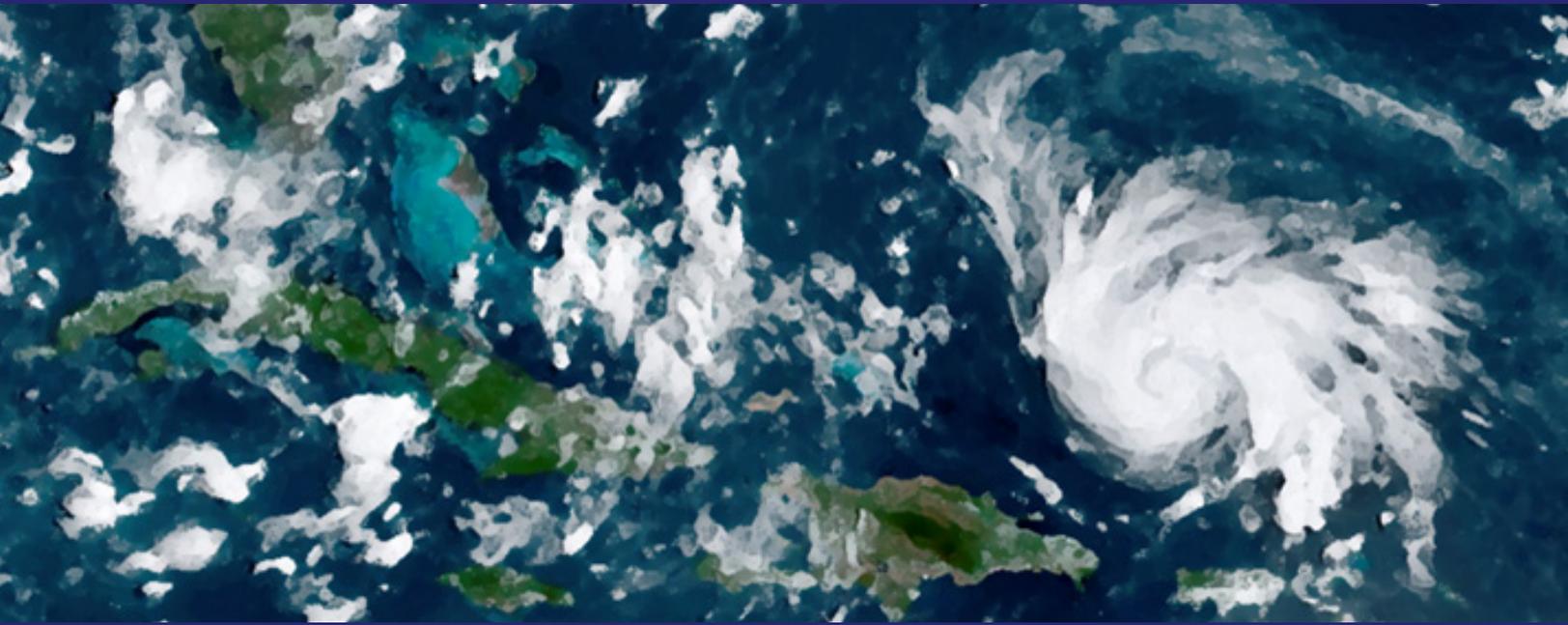


Hurricane Dorian and its forecasts: A great challenge in the 2019 hurricane season

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Each year, during hurricane season, the cyclone alert mechanisms come to the forefront through media and social platforms. These are products that come into being through meteorological forecasting and which give an idea of the projected scenarios for the hurricane season. One of their aims is to alert citizens to the possible formation of cyclones and their impacts, so that people can prepare for their possible arrival. When the projections change and the forecasts “fail”, it is common to see people become confused, frustrated and anxious. Furthermore, this can produce distrust and loss of credibility towards the cyclone alert mechanisms and, as a consequence, lack of action when facing new cyclonic threats.

This document presents an example of an erratic weather phenomenon: Hurricane Dorian, which had major changes in meteorological projections, and which surprised the scientific community and the general public. In this publication, we will describe Dorian’s trajectory and changes in forecasts since its formation until its near strike on Puerto Rico, while offering some reasons that could have influenced these changes. Hurricane Dorian resulted in catastrophic damages to the Bahamas, and reached a historic record for wind speeds in Atlantic hurricane history, since it reached wind speeds of up to 185 mph.

How Dorian was born...

On Friday, August 23rd, 2019, a tropical wave near latitude 10.0°N and longitude 42.0°O started being monitored. It had been 7 days since the meteorological models had suggested the possible formation of this tropical wave, although the models predicted it would weaken and eventually dissipate as it reached the Caribbean region. Therefore, the National Hurricane Center (NHC) initially gave it a low potential for development - just 10% to 20% - on that Friday morning. This potential rose significantly throughout the day, up to 50% in the afternoon and up to 70% in the evening. By 11:00 am of the following day, the tropical wave had developed into tropical depression #5, and as Tropical Storm Dorian 6 hours after that.

Dorian's evolution...

The first forecast for this cyclone pointed at a gradual intensification until it was classified as a hurricane. In other words, and contrary to what the models suggested, the NHC favored a strengthening scenario for this atmospheric system as it moved along Caribbean waters. As a matter of fact, this first forecast projected it as a Category 1 hurricane with 85 mph winds which would be moving across waters to the southern coast of Puerto Rico during the morning of Thursday, August 29th. That afternoon, the forecast was adjusted to a similar scenario in terms of route and intensity, but the timing was rolled forward; now it was supposed to go by Puerto Rico on the afternoon of Wednesday, August 28th, and the closest it would come to the Island would be between Cabo Rojo and Mona Island. From there, it was projected that the center of the hurricane would directly impact southeast Dominican Republic.

Given the cyclone's proximity and the models' projections placing Dorian between Hispaniola and Puerto Rico, a tropical storm watch was emitted on Monday, August 26th. At that time, the hurricane projection was still prevalent in NHC, but global models suggested a lesser intensity. In fact, Tropical Storm Dorian hadn't shown any further strengthening nor a more organized structure. When the hurricane hunter aircraft flew over the atmospheric phenomenon, they only found sustained winds topping at 50 mph.

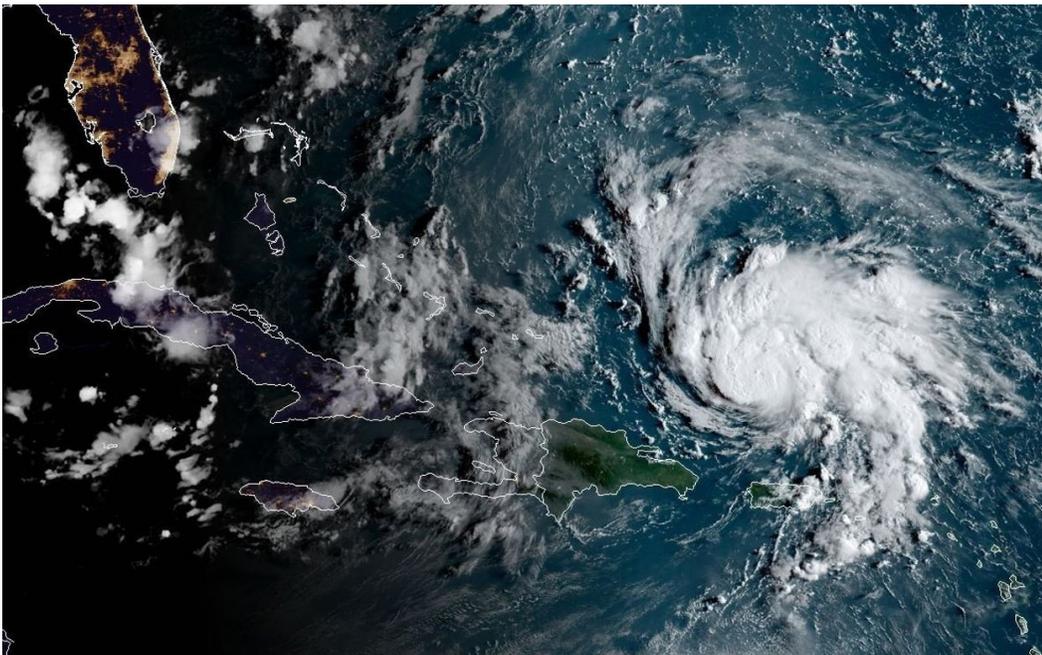
That measurement of 50 mph was even less than projected by satellite imaging (which projected 60 mph); more reliable information about a cyclone's intensity and other atmospheric conditions can't be collected until it comes closer to a territory or to data-gathering buoys. In fact, the hurricane hunter aircraft is only assigned when a storm comes close to a territory, which was why the aircraft was deployed when Dorian got closer to Barbados. This difference in wind speeds translated to a slight adjustment in the forecast. Although the NHC continued projecting a Category 1 hurricane, the wind speed forecast dropped the wind speed to 75 mph, as opposed to the earlier forecast of 85 mph winds.

While the forecasts about the storm's intensity was changing, so was its route, putting the storm closer to southwest Puerto Rico, a pattern also displayed by the spaghetti models. As if forecasting this storm's intensity wasn't challenging enough, on Tuesday, August 27th, Dorian relocated its circulation center further north, which led to the NHC project a direct strike over Puerto Rico; in other words, the forecast had changed again. Another of the adjustments happening at that time was that Dorian was not expected to strengthen as a hurricane but would drop down to a storm with winds of around 60 mph. On Tuesday afternoon, Ponce and Aguadilla were pointed out as the entry and exit points for Dorian on the Island. However, further adjustments were made and the new route across the Island projected by the NHC placed the storm as entering through Yabucoa and exiting through Manatí.

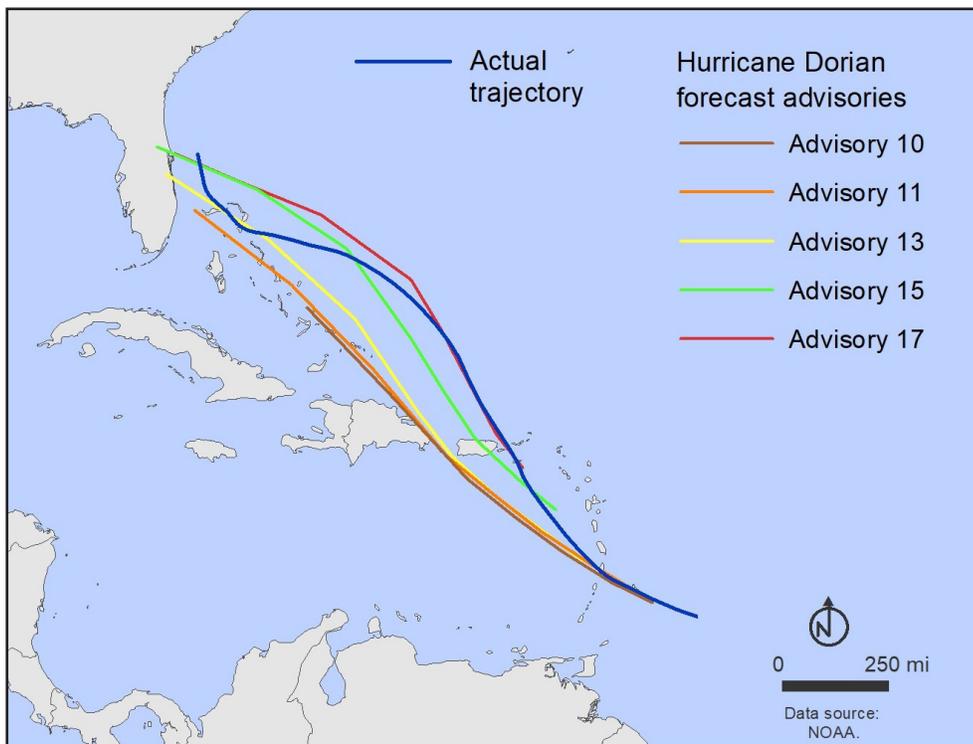
The readjustments continued and by Wednesday, August 28th, the projection showed Dorian grazing the northeast corner of the Island, between Ceiba and Río Grande. So, from it being that the western side of the Island would be receiving the brunt of the storm, the scenario had become completely inverted: it was now the eastern side that was the most directly threatened. This all happened over approximately 12 hours' period. Furthermore, the storm had organized and intensified, with winds at around 60 mph. By 11:00 am, Dorian had winds of up to 70 mph. With only four more miles per hour to go to reach Category 1 hurricane status, the initial forecast stating it would be a hurricane took precedence. However, the hurricane's movement showed a more northerly direction, which took it further from Puerto Rico's mainland, but closer to the island towns of Vieques and Culebra. Therefore, the trajectory was adjusted towards Culebra, where a hurricane warning was emitted on that same morning. This warning also applied to Vieques. The rest of Puerto Rico was under a tropical storm warning.

At the end of it all, only the island municipalities experienced tropical storm winds, especially Culebra. On that Wednesday, it rained towards the west and southwest portions of the Island, an everyday pattern for that time of the year. There was some rainfall on the eastern side of the Island, but it wasn't extraordinary. In fact, total rain accumulation was less than 3 inches. By that afternoon, Dorian was already northeast of the Island as a hurricane with 80 mph winds, and most of Puerto Rico had a relatively pleasant afternoon... Dorian had gone past and it was barely felt in the Island.

By Thursday, August 29th, everyday labors were resumed, although the hurricane's tail brought more rain than the hurricane's main clouds when it passed 20 miles northeast of Culebra. On that day, up to 6 inches of rain were registered in Coamo and Aibonito, and between 4 to 5 inches in Luquillo and Maunabo. This caused serious flooding in the eastern side of the Island. Meanwhile, the forecasts now suggested that Dorian would be turning into a Category 3 hurricane as it headed towards Florida during that last weekend in August, passing northeast of the Bahamas without greatly affecting them.

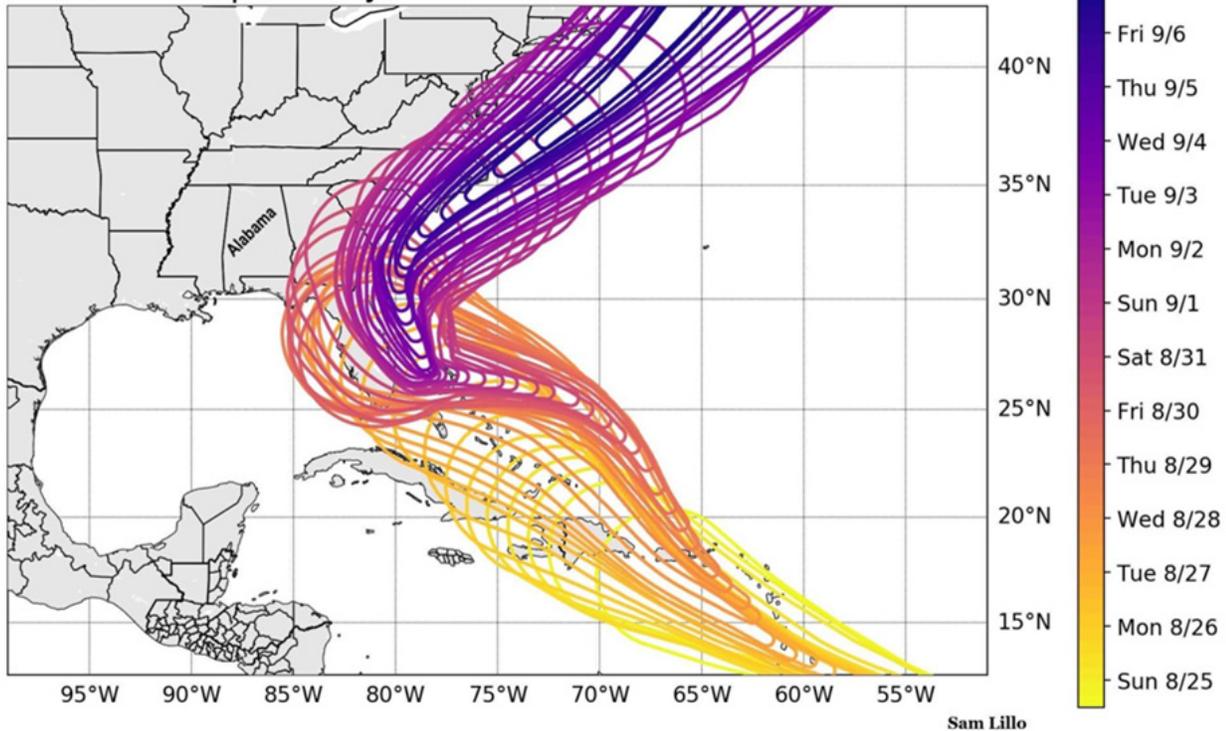


Dorian north of Puerto Rico and heading to the Bahamas.
[Source: NOAA]



The different trajectories projected during the forecasts between August 26th and 27th, and the final trajectory Hurricane Dorian took across the insular Caribbean.

Hurricane Dorian | NHC 5-day forecast cones



Trajectory cones provided in the forecasts emitted for Hurricane Dorian between August 25th through September 6th, 2019. The many readjustments made along the way can be clearly observed. Remember that the trajectory cone shows the possible route that the cyclone's center can take, and it is made up of an area in which the cyclone's center is expected to cross; it can move to any point within the cone's extension. [Source: S. Marshall, 2019].

The catastrophic outcome...

Contrary to what was initially projected, Hurricane Dorian became much stronger; so much so, that it became one of the most powerful hurricanes in the Atlantic basin. North of Hispaniola, Dorian quickly gained 35 mph to its wind speed, taking it from 105 to 140 mph. Unfortunately, Dorian unleashed its fury northeast of the Bahamas, in Abaco and Grand Bahamas Islands. There, severe winds, over two feet of rain and a nearly 20-foot cyclonic surge mercilessly lashed the islands for over 24 hours; Dorian had become stationary over the islands. It degraded and became a Category 4 hurricane.

The next target for Dorian seemed to be Florida; however, despite the models generally agreeing, there was a sudden readjustment. Two of the most globally known models, the GFS (American) and the ECWMF (European) projected the hurricane moving parallel to the coast off the Florida peninsula and eventually dodging the states between Georgia and the Carolinas.

It would leave copious rain, of course, along with strong surf and storm-strength winds, but the hurricane-strength winds would remain on Atlantic waters. Further on, the hurricane ended up generating major wind and rain impacts on the Carolinas, where the eyewall partially touched on the states as a Category 2 hurricane. Then, Dorian debilitated to a Category 1 hurricane and produced rain and gusty winds across northeast continental United States. On Saturday, September 7th, Dorian surprised everyone again by gathering energy once more and strengthening from Category 1 to Category 2 (with 100 mph winds) just before entering Nova Scotia, Canada.

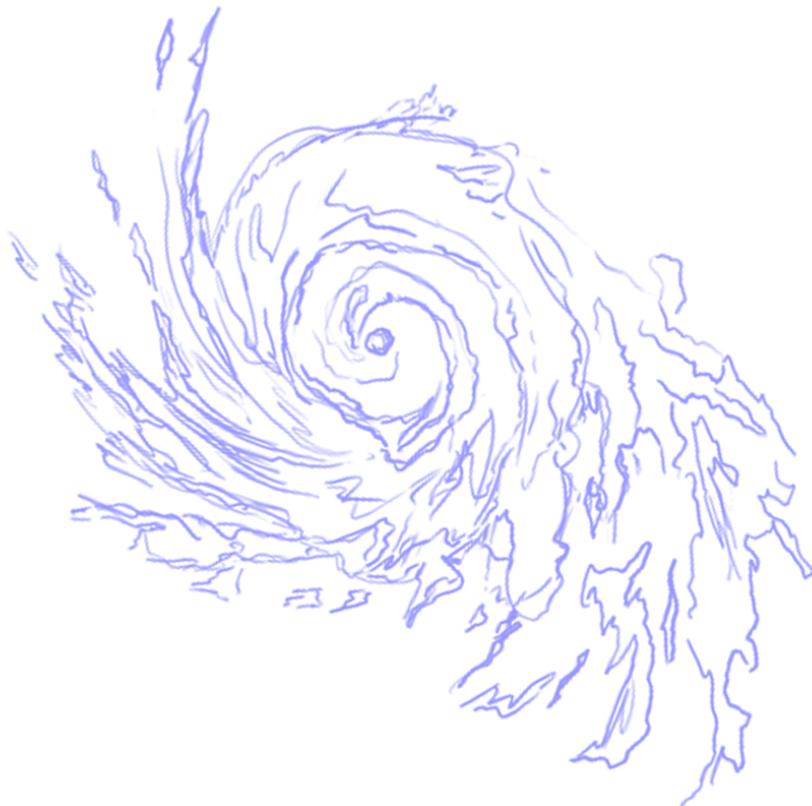


Hurricane Dorian's final trajectory.

In the end, they are forecasts...

There's no doubt that the changes in Hurricane Dorian's trajectory and intensity were numerous; however, we cannot forget the fact that, in the end, these are forecasts. In Dorian's specific case, dry air and wind shear in our proximity limited the storm's initial development. This made the system's energy pulse and change its structure constantly. Furthermore, the system was initially very compact, which made it difficult for models to recognize it as an entity and how it would behave as a cyclone in its surrounding environment. Once it struck the Bahamas, its reduced translation movement, the presence of a high pressure system just north of the hurricane while there was a low pressure area towards the Great Lakes all had an important role in the hurricane's future outcome. All of this complicated the process of understanding the most likely scenario for this hurricane, which kept Florida on its toes. In fact, the low-pressure system on the Great Lakes area would be responsible for the high pressure north of Dorian weakening and thus helping Dorian gain speed and a northeast direction, keeping to the states along the east coast of the United States.

We should also keep in mind that meteorology is not an exact science with 100% predictability, and much less so when referring to tropical conditions. In fact, the National Hurricane Center highlights that statistically, 1 out of 3 systems move beyond the trajectory cones. In the case of Dorian, Puerto Rico and Florida both were part of that 33% of the times in which what was forecast does not happened and we 'escaped' the hurricane. Meanwhile, other regions which were not initially projected to be struck suffered a harsh impact from this powerful storm. Therefore, despite having new technology and weather guides, we cannot lose sight of the fact that nature's conditions will dictate the final trajectory and outcome of atmospheric events.



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