EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

2 September 2019,14:30 UTC

HURRICANE DORIAN in the Bahamas and USA

UPDATE #1

02 Sep 2019 - ongoing

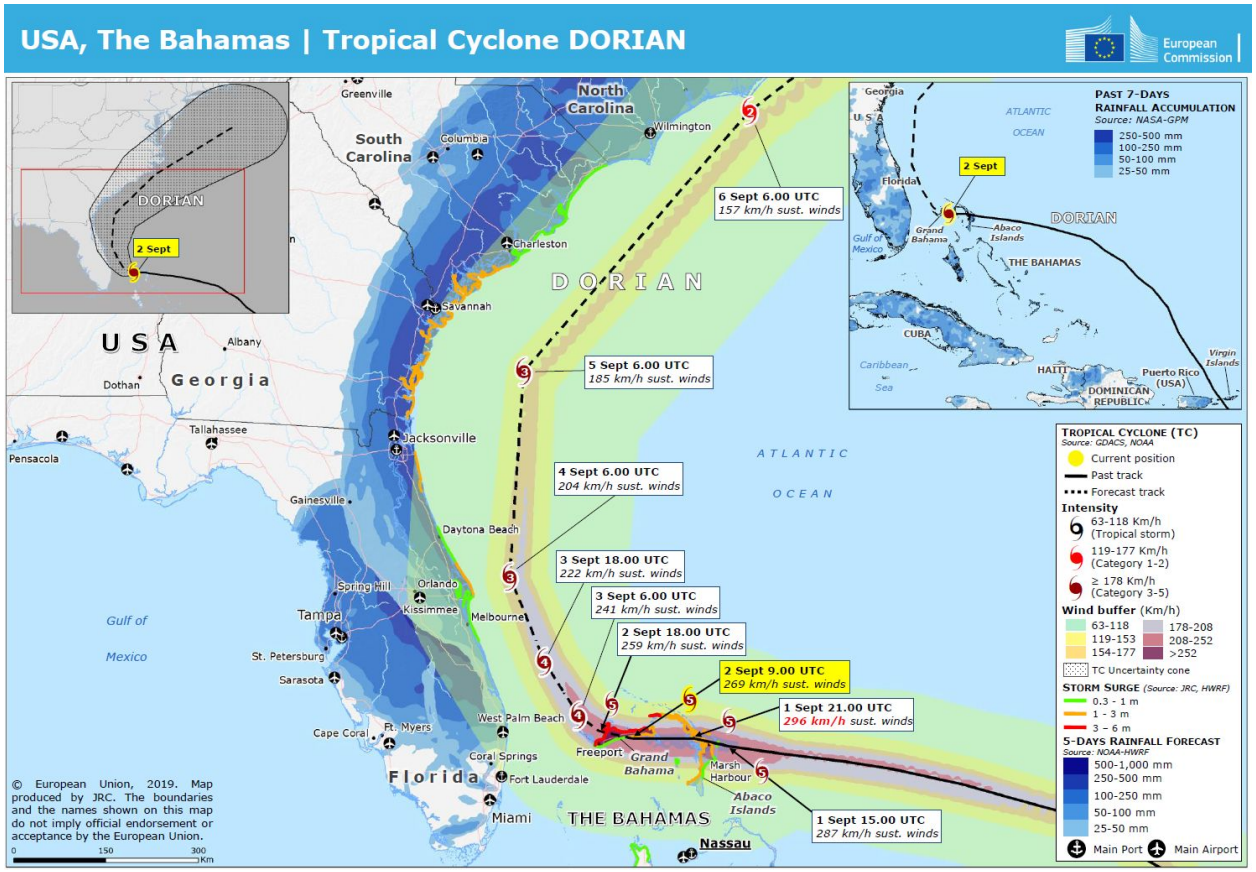


***Figure 1** - TC DORIAN in the USA, Bahamas and Caribbean (as of 02 September, 09:00 UTC)*

1. Executive Summary

- The Hurricane **DORIAN** is moving **slowly** through the north-western Bahamas as a **devastating Category 5 Hurricane**, with **very strong winds**, **large storm surge** and **very heavy rainfall**. On 02 Sep at 09:00 UTC, its center is located near Freeport (Grand Bahama) and had max.

sustained winds of 270 km/h. Its slow movement tends to increase the impact on the Bahamas islands.
- According to the latest forecast, its centre could leave the Bahamas on 3 September morning (UTC) and move close to the coast of south-eastern USA (Florida, Georgia, South Carolina and North Carolina) on 3-6 September, still as an intense Hurricane. The track uncertainty is still large, but it should be noted that although the eye is currently predicted to remain over the sea, the effects of DORIAN could be widely felt along the south-eastern coast of the USA.
- Based on this forecast, very strong winds, heavy rainfall and storm surge could still affect north-western Bahamas on 2-3 September, and south-eastern USA on 3-6 September.

- In **the Bahamas**, heavy rainfall, strong winds and storm surge are currently affecting in particular the **Abacos** and the **Grand Bahama**. One person is reported dead. On the Abaco Islands, parts of the main city **Marsh Harbour** are flooded, and power and water outages were reported. Floods have been reported in several areas on the island of **New Providence**. Residents of one of the vulnerable neighborhoods in Marsh Harbour, called **the Mudd**, have been severely affected. Residents are mostly migrants from Haiti. They took advantage of a pause as the storm passed over to leave their damaged and flooded homes and seek safety in the main government building

- The US States of **Florida, Georgia and South Carolina** issued evacuation orders for their coastal counties on Sunday night. The evacuation orders of Florida, South Carolina and Georgia together imply at least 1 million people to evacuate their coasts. In **Florida, Georgia, South Carolina, Puerto Rico and U.S. Virgin Islands a state of emergency was declared** between 27 and 31 August.

- The Joint Research Centre (JRC) is following the event through the information automatically collected and analysed in the Global Disasters Alerts and Coordination System (GDACS) and by creating dedicated Emergency Reports. GDACS issued a **RED** alert for **TC DORIAN** in the **USA** and **Bahamas** on **30 August**.

- The European Commission's Copernicus emergency satellite mapping service was activated on 1 September at 10:46 UTC to provide satellite maps for the Abaco Islands.

2. Situation Overview

2.1. Meteorological Situation

Tropical Cyclone DORIAN

- **PAST**: After having moved through the Caribbean islands on 26-28 August, Hurricane DORIAN moved over the Atlantic strengthening into a very dangerous Category 5. It reached Abaco islands, near Marsh Harbour, on 1 September with max. sustained winds up to **295 km/h** and higher winds, then it crossed these islands and reached Grand Bahama still as a powerful Category 5 Hurricane.

- **CURRENT**: On 2 September at 09:00 UTC, its centre was located approx. 60 km east of Freeport (Grand Bahama island) and 190 km east of West Palm Beach (Florida, USA), with max. sustained winds o**f 270 km/h** (Category 5 Hurricane). It is moving very slowly over the Grand Bahama island worsening the impact situation, since it could stay over the Bahamas for a prolonged period, with devastating winds, very heavy rainfall and extensive storm surge.

- **FORECAST** (as of 2 September, 09:00 UTC TC data): it is forecast to continue moving over Grand Bahama as a Category 5 Hurricane and start moving away from the Bahamas on 3 September. Its center is forecast to move over the Ocean, passing close to the coast of Florida on 3-4 September, Georgia and South Carolina on 5 September. Although the eye is predicted to remain over the sea, the effects of DORIAN could be widely felt along the south-eastern coast of the USA. There is still a large uncertainty on the forecast track/intensity.

- **UNCERTAINTY**: It is forecast to move close to the coast of south-eastern USA on 2-6 September, but there is some uncertainty about how far the TC's centre will move from the coasts and if it makes landfall in North Carolina on 6 September (see Figure below).

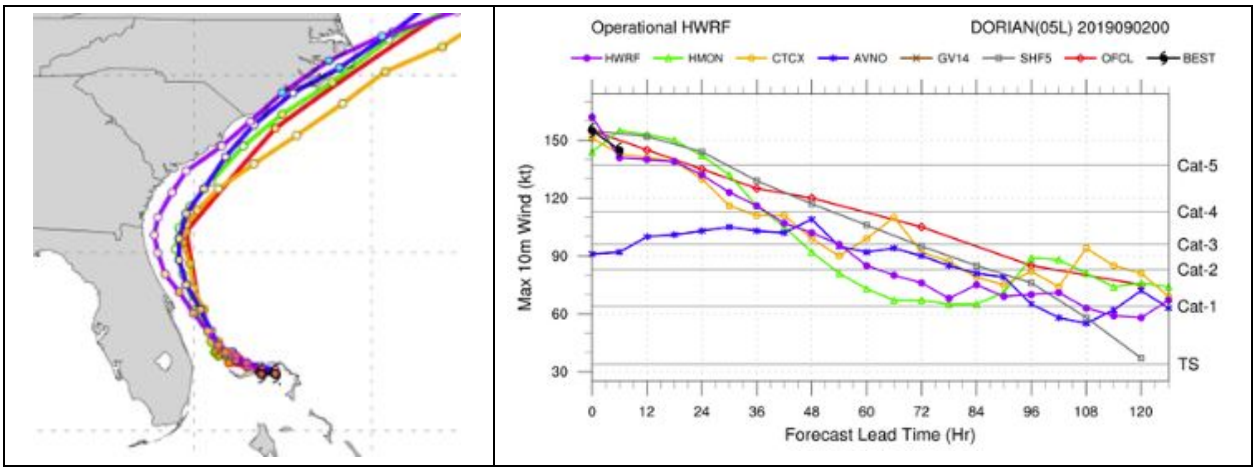


***Figure 2** - TC DORIAN uncertainty track/intensity (as of 2 Sep, 00:00 UTC).*
Sources: NOAA-HWRF

Areas potentially most affected:

Overview: Major Hurricane-force winds (Category 5), **very heavy rains** and a **large storm surge are affecting north-western Bahamas**, including the city of **Freeport**, and could still affect this area on 2-3 September. In addition, heavy rains, strong winds and storm surge could also affect the eastern coast of south-eastrn USA (Florida, Georgia, South Carolina, North Carolina) on 3-6 September.

NOTE: Since it is moving very slowly, it could stay over the Bahamas for a prolonged period, with devastating winds, very heavy rainfall and large storm surge and this could worsen the situation.

The possible impact (strong winds, heavy rains and storm surge) of Hurricane DORIAN in the Bahamas and USA is shown in the table below. For the USA, the track and intensity are still uncertain.

Impact Estimation: Areas potentially most affected	
Wind	**Max sustained winds: Category 5 (**up to 295 km/h, with higher gusts**)** ● **Bahamas:** ○ North-western Bahamas (Hurricane winds, up to Category 5), especially in the islands of Abaco and Grand Bahama (including Freeport). ○ Central Bahamas (Tropical Storm winds) ● **USA:** ○ Eastern coast of south-eastern USA (Florida, Georgia, South Carolina, North Carolina), (Hurricane/Tropical storm winds)
Rain	● **Bahamas**: ○ North-western Bahamas: 300-600 mm, isolated 800 mm ○ Central Bahamas: 50-100 mm, isolated 150 mm ● **USA**: ○ Coastal area from Florida to Georgia: 50-100 mm, isolated 150 mm ○ Coastal Carolinas: 100-250 mm, isolated 400 mm **NOTE:** The total amount could also locally be higher than 1000 mm in the north-western Bahamas. This amount is well above the monthly average of September, that is for Freetown (Bahamas): 217 mm.
Storm Surge	● **Bahamas**: ○ North-western Bahamas: **1.2 m measured** in Freeport on 2 Sep, 10:00 UTC; much higher values (> 4m) are forecast in northern coastal areas of Grand Bahama ● **USA**: ○ South-eastern USA (JRC calculations limited to 72h, maximum not yet reached in Georgia, South Carolina, North Carolina and Virginia)

***Table 1** – Areas potentially most affected by TC DORIAN*

Warnings in effect

As of 02 Sep, 09:00 UTC, there are the following warnings/watches in effect (see Table and Figure):

Hazard	Warning		Watch	
STORM SURGE	*** Lantana to the Volusia/Brevard County Line** *** Albemarle and Pamlico Sounds, including the Neuse and Pamlico Rivers**		** North of Deerfield Beach to south of Lantana* ** Volusia/Brevard County Line to the Mouth of the St. Mary's River*	
WIND	**Hurricane**	**Tropical Storm**	***Hurricane***	***Tropical Storm***
	*** Grand Bahama and the Abacos Islands in the northwestern Bahamas** *** Jupiter Inlet to the Volusia/Brevard County Line**	*** North of Deerfield Beach to Jupiter Inlet**	** North of Deerfield Beach to Jupiter Inlet* ** Volusia/Brevard County Line to the Mouth of the St. Mary's River*	** North of Golden Beach to Deerfield Beach* ** Lake Okeechobee*

***Table 2** - TC DORIAN Warnings/Watches in effect*
(Source: NOAA-NHC and the Bahamas Department of meteorology: http://www.bahamasweather.org.bs/)
Definitionio Hurricane Warnings, Watches see https://www.nhc.noaa.gov/watchwarn_changes.shtml

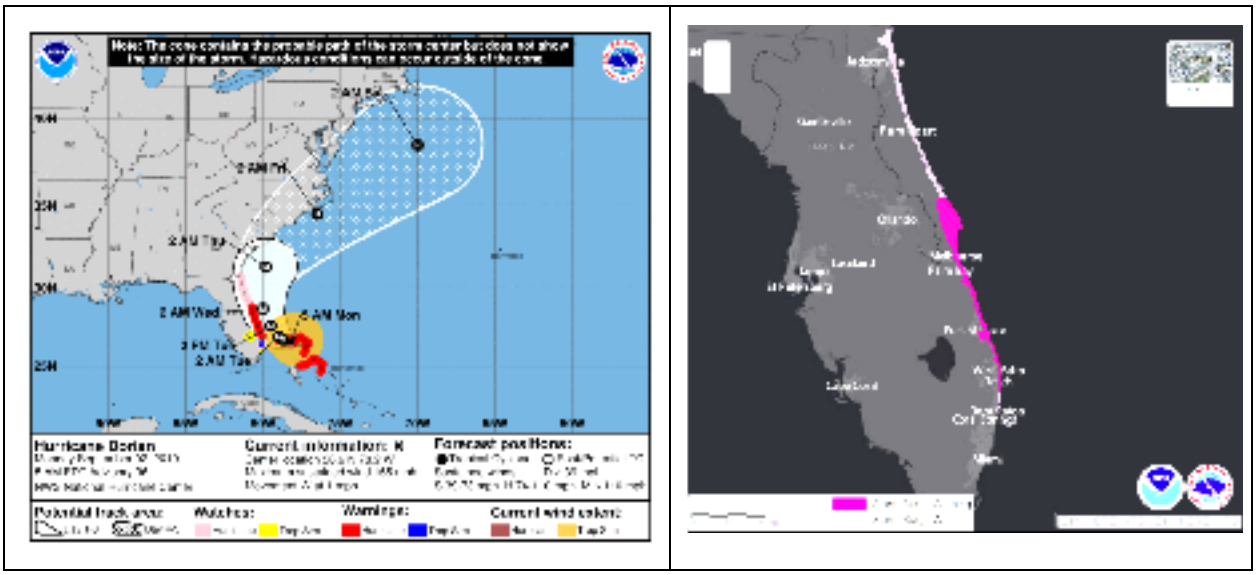


***Figure 3** - TC DORIAN Tropical Storm and Hurricane Warnings/Watches in effect (left), Storm surge Warnings/Watches in effect in the USA (rightl).*
(Sources: NOAA-NHC and the Bahamas Department of meteorology)

Storm Surge

One of the strongest effect of the hurricane is the large storm surge. In the case of Bahamas only one tide gauge is available and is located in the far north west of the Grand Bahamas island. This measurement shows the passage of the hurricane with a clear exceedance of the astronomical tide of about **1.2 m** but it should be noted that this is not the location in the Bahamas where the maximum value is forecasted (see chapter on GDACS estimations).

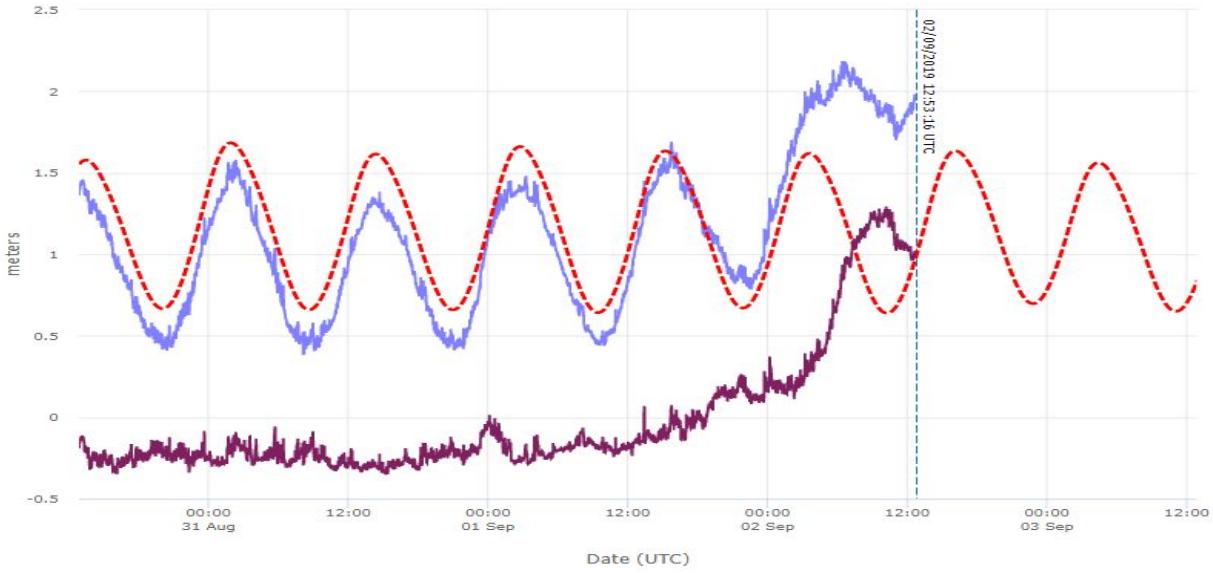


***Figure 4**: **Water level.** Blue is the measurement (WL), dashed red is the astronomical tide (TD) and dark red is the storm surge, SS (SS=WL - TD)*

The measured signal in Freeport, Bahamas shows the sea level at the moment and the maximum is expected in about at about **14:30 UTC**; a minimum in the tide is expected and so the impact of the storm surge is slightly lower than in case of a maximum value of the tide. The current value of the maximum measured in Freeport is about **1.2 m**.

2.3 Humanitarian impact and Preparedness

Bahamas

Heavy rainfall, strong winds and storm surge are currently affecting the Bahamas, in particular the **Abacos** and the **Grand Bahama** islands. On the Abaco Islands, parts of the main city Marsh Harbour are flooded, and power and water outages were reported. According to media a seven year old boy is dead in Abaco island on Sunday and his sister is still missing.
The hurricane warning[1] reports that catastrophic hurricane conditions are occuring in the Abacos and Grand Bahama and will continue for the next several hours. Meanwhile, floods have been reported in several areas on the island of **New Providence**.

Prime Minister Hubert Minnis announced an evacuation order for parts of Grand Bahama and the Abaco Islands; all tourists were asked to leave. He had warned that 73,000 residents and 21,000 homes could be affected and urged residents of the Grand Bahama Island on Sunday to move to safer ground in the main city of Freeport. On the Abaco Islands, parts of the main city of Marsh Harbour flooded[2].

Residents of one of the vulnerable neighborhoods in Marsh Harbour, called **the Mudd**, have been severely affected[3]. Residents are mostly migrants from Haiti. They took advantage of a pause as the storm passed over to leave their damaged and flooded homes and seek safety in the main government building[4].

Around 15 years ago, **Hurricane Jeanne** affected the Bahamas in 2004, having a very similar track but with a lower intensity (Category 3 in the north-western Bahamas), just three weeks after **Hurricane Frances** (Category 2-3 in the north-western Bahamas), which caused two deaths and affected more than 8,000 people in Grand Bahamas Island. There were no reports of deaths or serious injuries, but flood waters rose to around 2 m in some areas and roofs were blown off of houses. **Hurricane Jeanne** impacted the north-western Bahamas, causing the most significant damage on the Grand Bahama and Abaco islands. **For that event, the international humanitarian support was requested.**[5] Recently, for TC IRMA in 2017, the Bahamas suffered of limited structural damage and international humanitarian support has been requested on bilateral agreements[6].

[1] Alert #35 on hurricane DORIAN issued by the Bahamas Department Of Meteorology Monday, 2nd September 2019 at 3am EDT.
[2] https://www.nytimes.com/2019/09/01/world/americas/hurricane-dorian-bahamas.html
[3] https://www.reddit.com/r/bahamas/comments/cyc1s8/haitian_shanty_town_the_mudd_in_abaco/
[4] https://www.nytimes.com/2019/09/01/world/americas/hurricane-dorian-bahamas.html
[5] https://reliefweb.int/report/bahamas/bahamas-hurricane-jeanne-appeal-no-2304-operations-update-no-2
[6] https://www.usaid.gov/crisis/bahamas

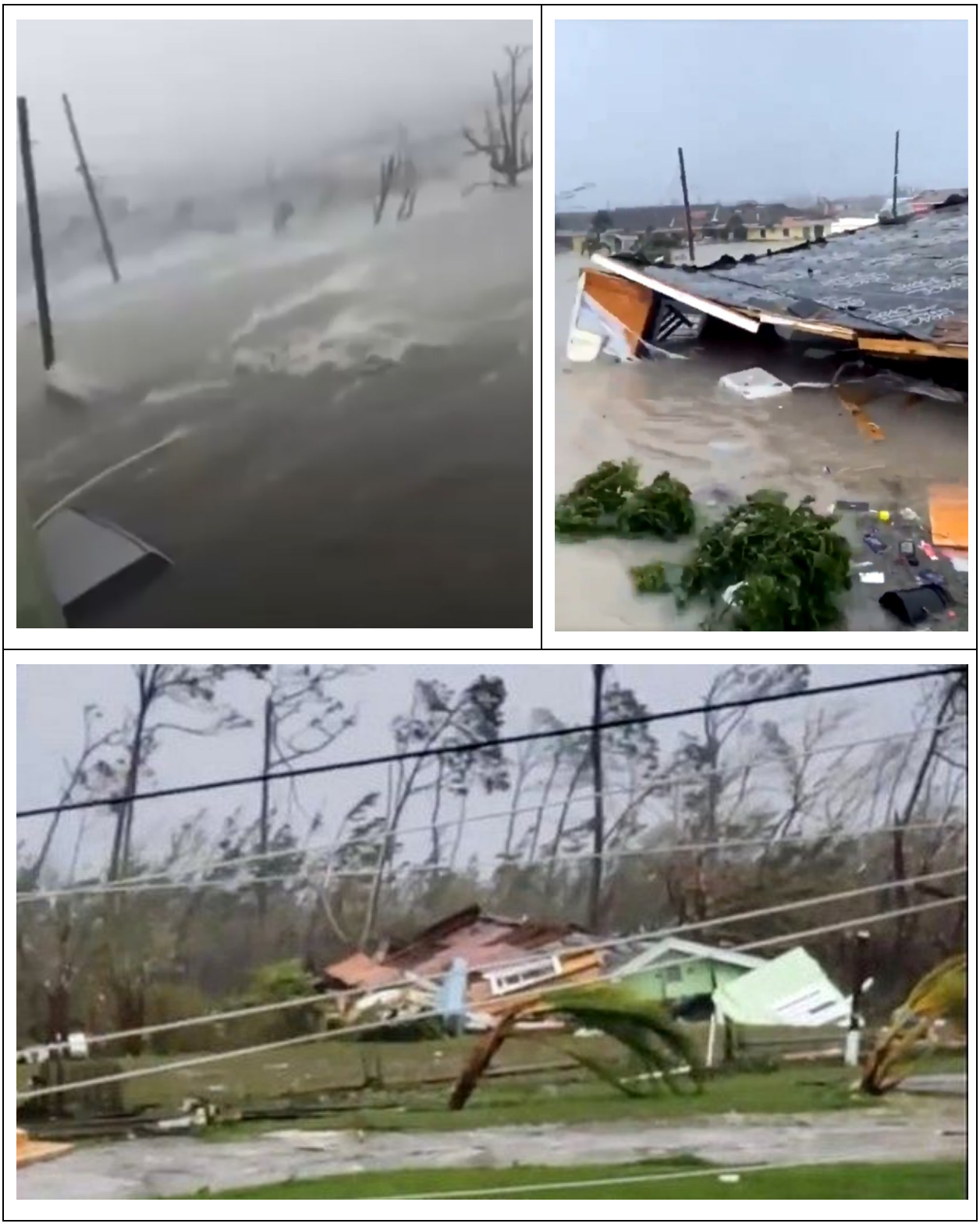


***Figure 5**: Heavy rainfall, strong winds and storm surge are currently affecting **Abacos** and the **Grand Bahama** islands (source: Twitter - left @mvp242, right @Brendeaaa. Bottom: https://www.bbc.com/news/world-latin-america-49541485)*

USA:

DORIAN caused limited damage in the northern Caribbean as it left the region Wednesday night. Some reports of power outages and flooding were reported across the **Puerto Rican islands of Vieques and Culebra and the U.S. and British Virgin Islands**.

The US States of Florida, Georgia and South Carolina issued evacuation orders for their coastal communities on Sunday night as the National Hurricane Center in Miami warned of storm surges that could reach 18ft to 23ft (5.5m-7m) above normal levels[7]. The evacuation orders of Florida, South Carolina and Georgia together imply at least 1 million people to evacuate their coasts.[8]

Preparedness actions are taking place in:

- **Florida:** mandatory evacuation orders have been issued[9] for six counties on the east coast: Brevard, Martin, Palm Beach, St. Johns, St. Lucie and Volusia. Six counties are under voluntary evacuation, based on the assessment of the recovery conditions (eg. low lying areas, manufactured homes): Osceola, Okeechobee, Indian River, Highlands, Hendry, Glades. Evacuation are ongoing. The Emergency Declaration has been signed on 29 Aug. (HQ-19-095) including all 67 counties.
- **South Carolina:** The South Carolina order covers all of Beaufort and Charleston counties and parts of the rest of the state's coastal counties, which state officials estimated covered 830,000 people. The Emergency Declaration has been signed on 31 Aug.
- **Georgia:** A mandatory evacuation order has been issued for individuals living east of Interstate Highway I-95, along the Atlantic coast, in Bryan, Camden, Chatham, Glynn, Liberty, and McIntosh Counties effective at noon on 2/9/19. Contraflow of I-16 will begin at 8:00 am Tuesday morning.The evacuation order includes Savannah and most of its 150,000 residents, as well as more than 50,000 in coastal communities like Brunswick, St. Marys and Richmond Hill. Naval Submarine Base Kings Bay, in Camden County, told its 15,000 military and civilian personnel and their families to expect an announcement soon. Emergency Declaration has been signed on 29 Aug. (HQ-19-096) for 12 counties on the eastern coast (Brantley, Bryan, Camden, Charlton, Chatham, Effingham, Glynn, Liberty, Long, McIntosh, Pierce and Wayne). An Executive Order was issued temporarily suspending federal rules and regulations which would otherwise limit the hours that operators of commercial vehicles may drive to ensure an uninterrupted supply of petroleum products, emergency supplies, and food. This Executive Order also temporarily waives specific weight, height, and length restrictions for vehicles traveling through Georgia for purposes of disaster preparation or relief, subject to Department of Public Safety oversight and permitting.
  Ahead of the storm's arrival the Atlanta Motor Speedway is opening its camping facilities to evacuees seeking refuge from Hurricane Dorian. (source: Georgia emergency management and homeland security agency: https://gema.georgia.gov/).

[7] Georgia emergency management and homeland security agency: https://gema.georgia.gov/
[8] https://www.nbcnews.com
[9] https://www.floridadisaster.org/evacuation-orders/

3 GDACS System for TC DORIAN

JRC is responsible for the operation of GDACS (www.gdacs.org) that plays a major role in alerting the international community to humanitarian emergencies during natural disasters. The alerts of GDACS (Green, Orange, Red) are based on the severity of the event, the population involved and the vulnerability of the countries (see Annex). GDACS also sends e-mail and SMS alerts to subscribed recipients.

The JRC started closely following TC **DORIAN** because of the vulnerability of the Caribbean islands potentially affected, that were severely affected by Hurricanes **IRMA and MARIA** in 2017**.**

Event alert

GDACS has issued the first ORANGE Alert for this event in the Caribbean on 25 August 21:00 UTC, then reclassified as GREEN**,** due to a different forecasted track and intensity. It has issued a new ORANGE[10] alert of the USA and Bahamas on 28-29 August and this alert became **RED on 30 August**. According to the latest bulletin (02 Sep, 09:00 UTC), the GDACS alert level is **ORANGE** (for high winds) for this event in the **USA and Bahamas** with **190 000 people** in Category 1 or higher strength winds (>120 km/h).

The automatic GDACS reports can be found at: http://www.gdacs.org/report.aspx?name=DORIAN-19

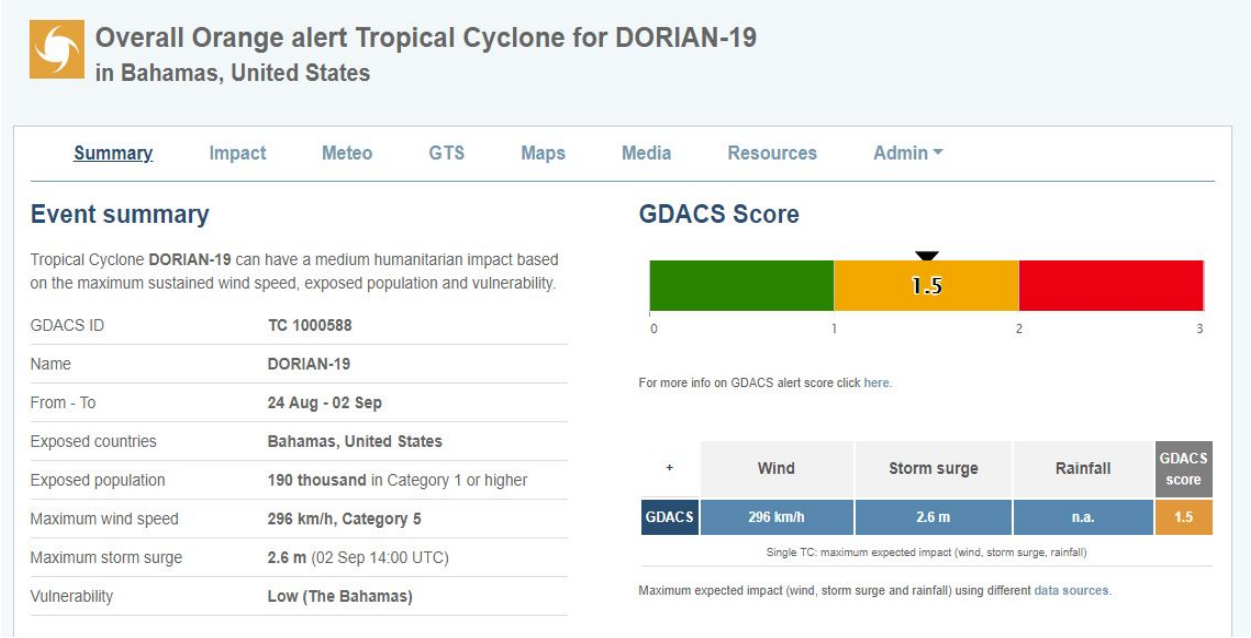


Figure 6 *- Automatic GDACS impact estimation (as of 02 Sep 2019, 09:00 UTC).*

[10] The alert for forecast greater than 3 days is limited to Orange level

Bulletin Timeline

Alert	N°	Date (UTC)	Category	Max winds (km/h)	Population in Tropical Storm	Population in Cat.1 or higher	Location (lat, lon)	Countries
	34	01 Sep 2019 21:00	Category 5	**296**	3.1 million people	60000 people	26.6, -77.3	Bahamas
	35	02 Sep 2019 03:00	Category 5	**287**	6.2 million people	51000 people	26.6, -77.9	Bahamas
	36	02 Sep 2019 09:00	Category 5	**269**	6.8 million people	49000 people	26.6, -78.2	Bahamas
	36	02 Sep 2019 18:00	Category 5	**259**	6.9 million people	47000 people	26.7, -78.7	Bahamas
	36	03 Sep 2019 06:00	Category 4	**241**	9.4 million people	46000 people	26.9, -79	Bahamas
	36	03 Sep 2019 18:00	Category 4	**222**	12.3 million people	39000 people	27.6, -79.5	United States
	36	04 Sep 2019 06:00	Category 3	**204**	10.7 million people	32000 people	28.7, -80	United States
	36	05 Sep 2019 06:00	Category 3	**185**	6.2 million people	81000 people	31.3, -79.8	United States
	36	06 Sep 2019 06:00	Category 2	**157**	2.6 million people	83000 people	34.5, -76.5	United States
	36	07 Sep 2019 06:00	Category 1	**139**	no people	no people	38.5, -70	

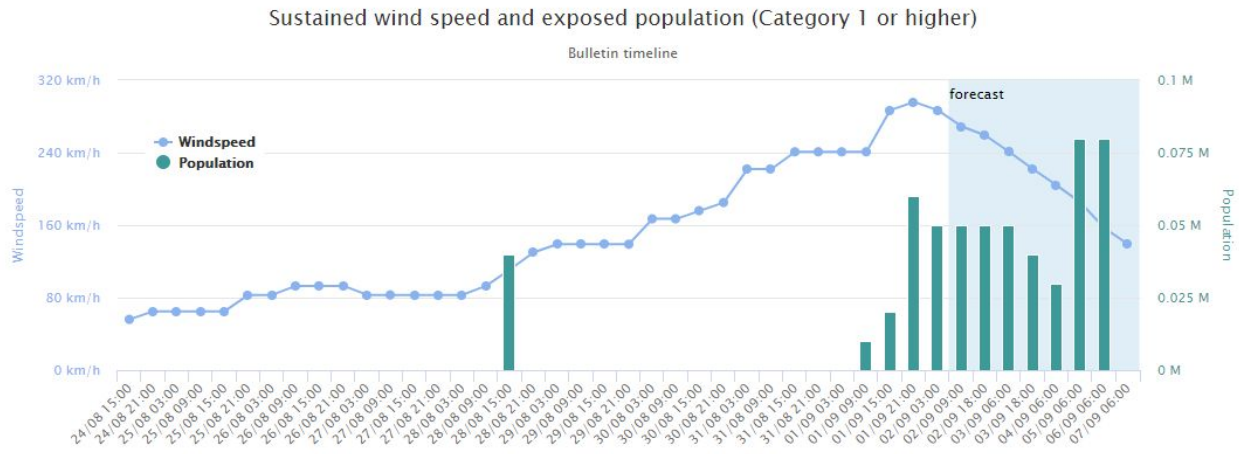


***Figure 7** - GDACS Alert for Tropical Cyclone DORIAN - Event Timeline, population exposed, max. sustained winds (Category: Saffir-Simpson Hurricane Scale), as of 02 Sep 2019, 09:00 UTC.*

Storm Surge Calculations and comparison with measurements

Several models are adopted in GDACS to estimate the storm surge; the various models uses different boundary conditions and different computer codes to have an indication of the spread of the estimations. The current values of the maximum predicted storm surge is between 2.9 and 5.9 m depending on the selected model, see below

+	Wind	Storm surge	Rainfall	GDACS score
GDACS	296 km/h	2.5 m	n.a.	1.5
Single TC: maximum expected impact (wind, storm surge, rainfall)				
HWRF	288 km/h	5.7 m	1662 mm	1.5
GFS	198 km/h	3.1 m	1337 mm	0.5
ECMWF	173 km/h	2.9 m	1495 mm	0.5
Beta Version - All weather systems in the area: maximum expected impact (wind, storm surge, rainfall)				

Figure 8: *All models indicates that the maximum of the storm surge should occur at about 2 Sep 2019 morning*

The reference calculation, that we consider more accurate is obtained using the HWRF meteorological model by NOAA and therefore even more detailed calculations were performed with this model.

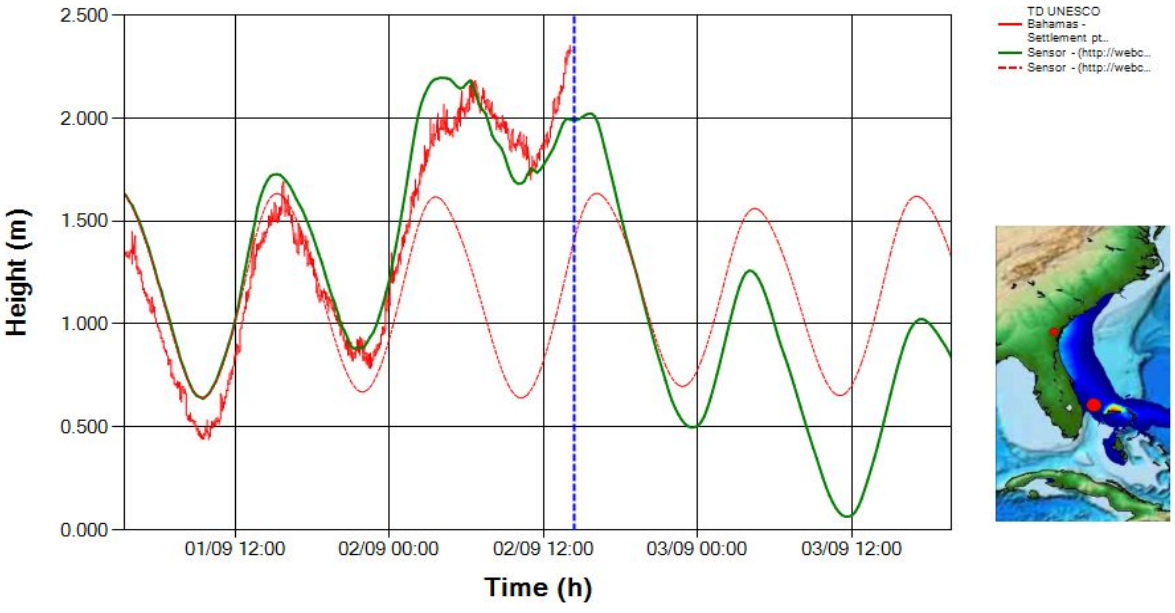


Figure 9: **Water level.** Red solid curve is the measurement, Green is the expected level and dashed red is the astronomical tide

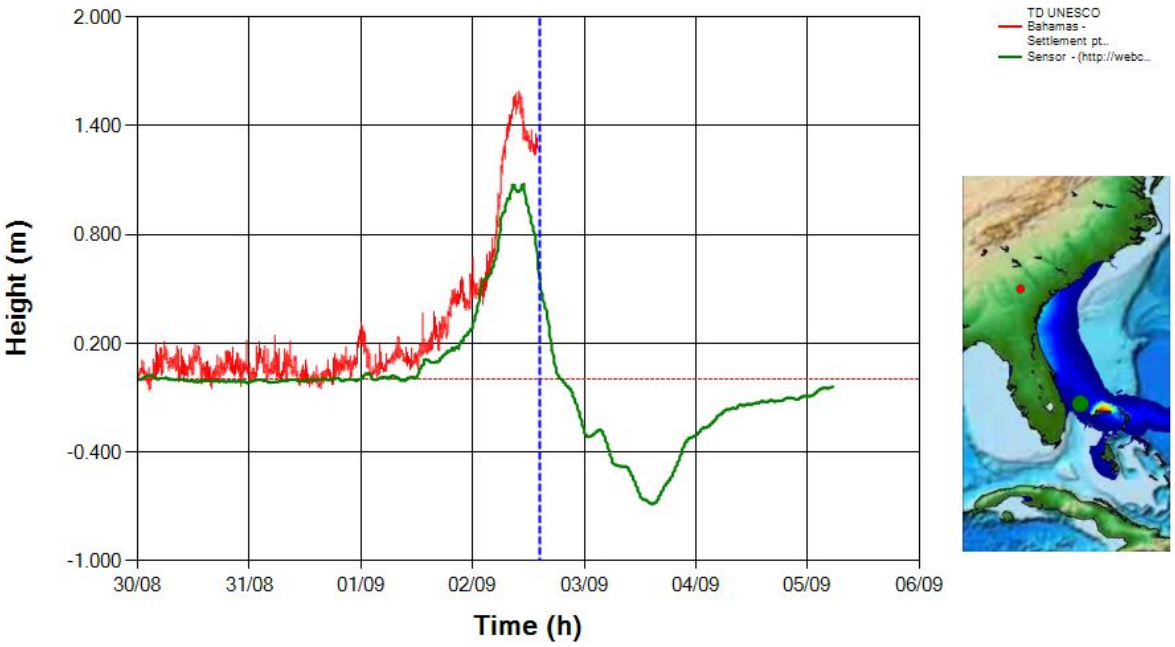


Figure 10: Storm Surge. *The red curve is the measured curve, Green is the expected storm surge.*

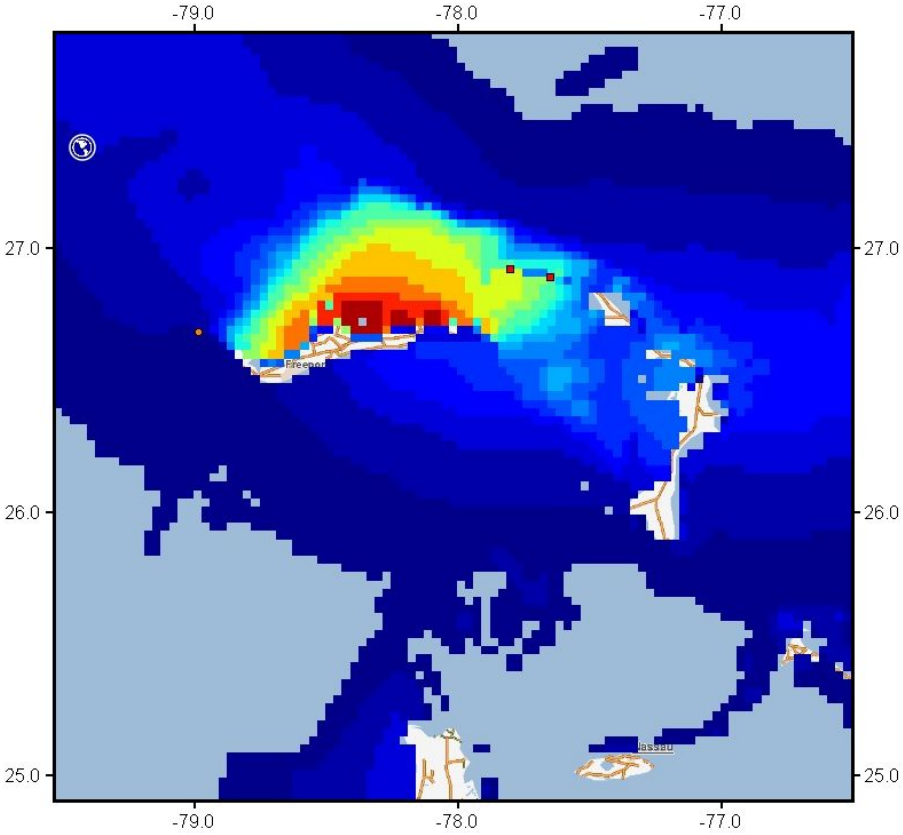


Figure 11: *Storm surge distribution in the Bahamas islands*

The detailed Storm surge distribution shows that most of the high value is concentrated in the northern side of the Grand Bahama Island, due to the shallow area that tends to increase the amount of storm surge. Values up to 3.5-6 m are expected there with the HWRF model (that generally provides the largest impact). Concern has been expressed for the great Abac island where however the expected height is lower, in the order of 1.2 m.

For the rest of the track the current predicted impact shows most of the impact in USA is in Florida.

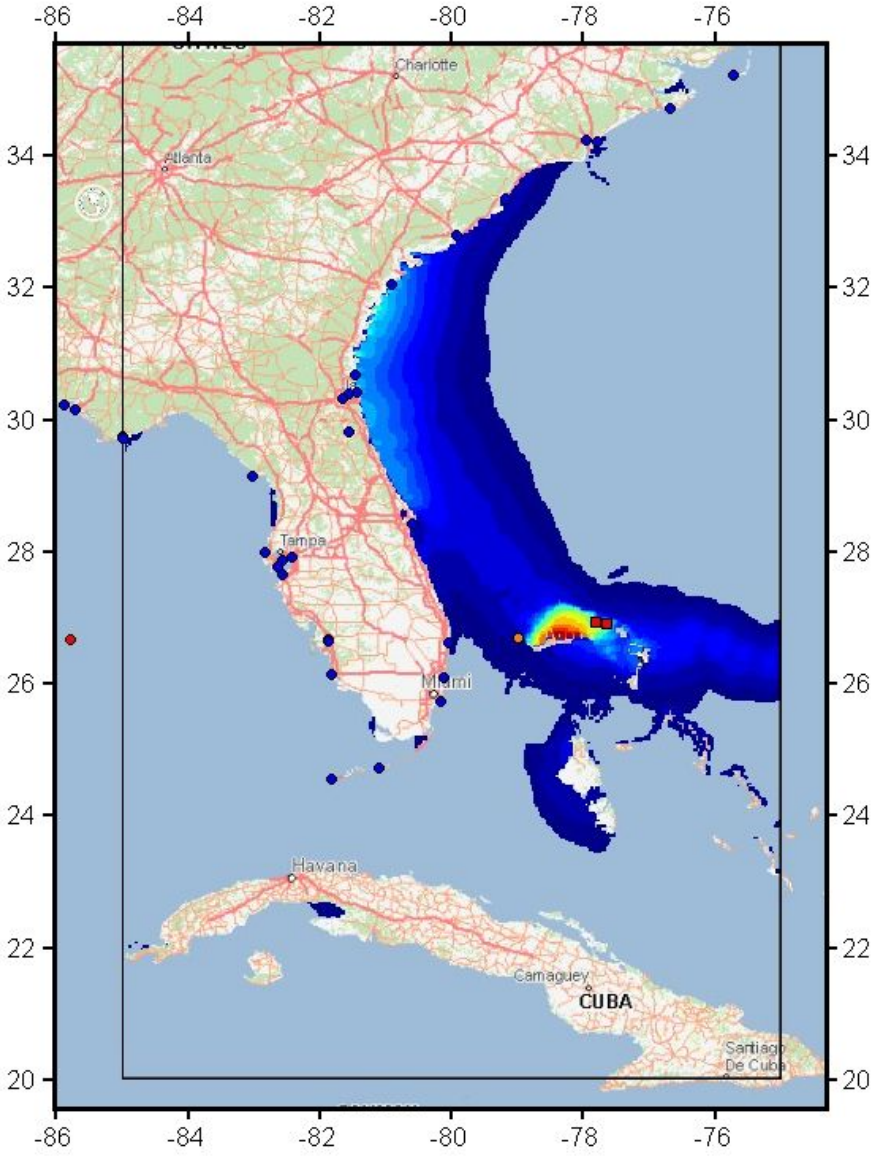


Figure 12: *Storm surge in the whole track of the DORIAN Hurricane*

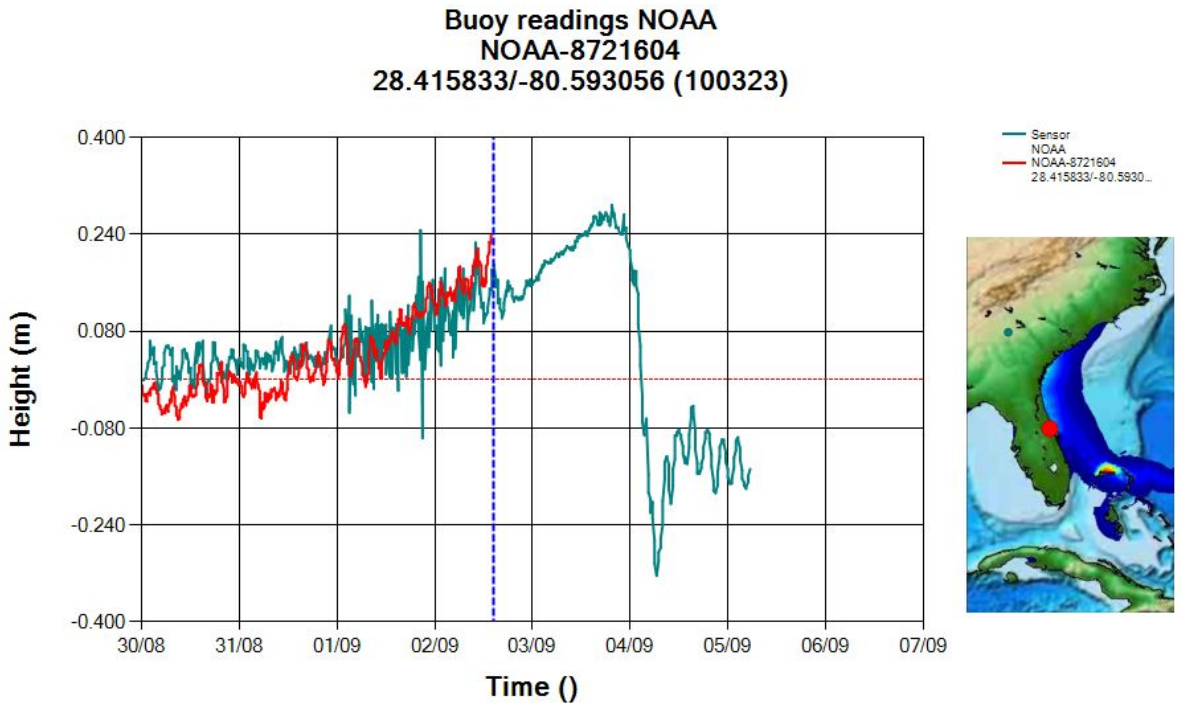


Figure 13: Storm surge in Angel City, Florida where the signal of the arriving cyclone is already present. Here the maximum value is expected to be reached on 4th Sep at 2:43 UTC but should be lower than in the Bahamas, about **1-1.5 m**.

Calculation based on the bulletin of 02 Sep 2019 00:00 UTC (**Overall** situation)

Alert	Date (UTC)	Name	Country	Storm surge height (m)
	02 Sep 2019 07:00	High Rocks	The Bahamas	5.7
	02 Sep 2019 09:30	Hawksbill	The Bahamas	4.5
	02 Sep 2019 09:30	Freeport	The Bahamas	4.5
	02 Sep 2019 06:15	Crown Haven	The Bahamas	3.3
	02 Sep 2019 06:15	Fox Town	The Bahamas	3.3
	02 Sep 2019 03:45	Cedar Harbor	The Bahamas	2.4
	04 Sep 2019 16:30	Isle of Palms	United States	2.0
	04 Sep 2019 16:30	Palm Valley Landing	United States	2.0
	04 Sep 2019 16:30	Jacksonville Beach	United States	2.0
	04 Sep 2019 16:30	Palm Valley	United States	2.0
	04 Sep 2019 16:30	Ponte Vedra Beach	United States	2.0
	04 Sep 2019 16:30	Sawgrass	United States	2.0
	04 Sep 2019 16:30	Mickler Landing	United States	2.0
	04 Sep 2019 16:30	Casa Cola	United States	2.0
	04 Sep 2019 16:30	South Ponte Vedra Beach	United States	2.0

***Figure 8** - Storm Surge affected locations of DORIAN in the Bahamas (> 2m).*

Note: *JRC storm surge calculations don't include wave, tide and river effects. It is important to note that in the area of a delta river, the storm surge may be higher. The torrential rains that may affect the mountains areas during the passage of a Tropical Cyclone may increase the river flow and its outflow could be blocked by the incoming storm surge. This could create floods in the surrounding areas of the cities close to a delta river.*

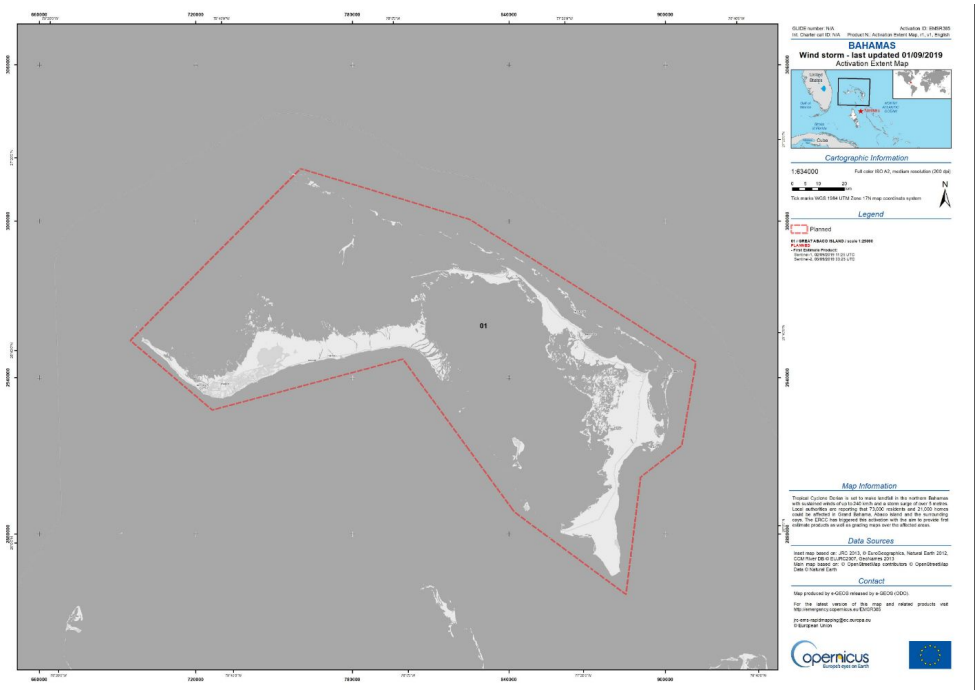
4 Other information

4.1 Copernicus EMS, Emergency Mapping Service

The Copernicus EMS Rapid Mapping was activated on 1 Sept 8:12 UTC by the ERCC with the objective to provide impact assessments for the Bahamas, once the cyclone has passed. The activation number is EMSR385 and is related to the mapping of Grand Bahamas and Abaco Islands.

Other areas might be added (currently in discussion is to extend to the New Providence island following reports for flooding in Nassau). The ERCC has triggered this activation with the aim to obtain first estimates of the impact (First Estimate Product FEP) and damage assessments over the affected areas. The first products will focus on providing rough impact estimates using Sentinel data (the first FEP from radar imagery is expected in the evening of 2/9, indicating flooded areas if any). In the coming days (weather permitting), optical imagery will be tasked to perform more detailed damage assessments over populated areas (areas will be defined based on the first assessments and other information).

The figure below shows the Activation Extent Map for this activation. The status of production including released products can be accessed at
https://emergency.copernicus.eu/mapping/list-of-components/EMSR385



4.2 Virtual OSOCC Activation

A breaking discussion has been activated on the 26 August on GDACS. Information sharing is ongoing among the humanitarian community. No request for assistance has been asked by the affected/exposed Countries and no team has yet deployed, waiting for more detailed situation assessment. The latest contribution and updates are of a few minutes ago.

4.2 International Charter for Space and Major Disasters

None.

5 Expected Updates

The report will be updated if relevant changes will be identified.

6 References and contact points

Contact points within JRC:
- Alessandro Annunziato, alessandro.annunziato@ec.europa.eu
- Pamela Probst, pamela.probst@ec.europa.eu
- Chiara Proietti, chiara.proietti@ec.europa.eu
- Marzia Santini, marzia.santini@ext.ec.europa.eu
- Annett Wania, annett.wania@ec.europa.eu

Unit Head and Deputy Unit Head:
- Alessandra Zampieri, alessandra.zampieri@ec.europa.eu
- Tom De Groeve, tom.de-groeve@ec.europa.eu

For updated information on the disaster, please consult the following web sites:

- GDACS: http://www.gdacs.org
- ERCC portal: http://erccportal.jrc.ec.europa.eu/
- National Meteorological service:
    - USA: https://www.weather.gov/
    - Bahamas: http://www.bahamasweather.org.bs/

- Regional Specialized Meteorological Centres (RSMCs):
    - RSMC Miami-Hurricane Center/NOAA/NWS National Hurricane Center, USA http://www.nhc.noaa.gov/index.shtml

- NOAA-HWRF (Hurricane Weather Research and Forecasting system): http://www.emc.ncep.noaa.gov/gc_wmb/vxt/HWRF/index.php

Annex 1 - Detailed Map on the Tropical Cyclone

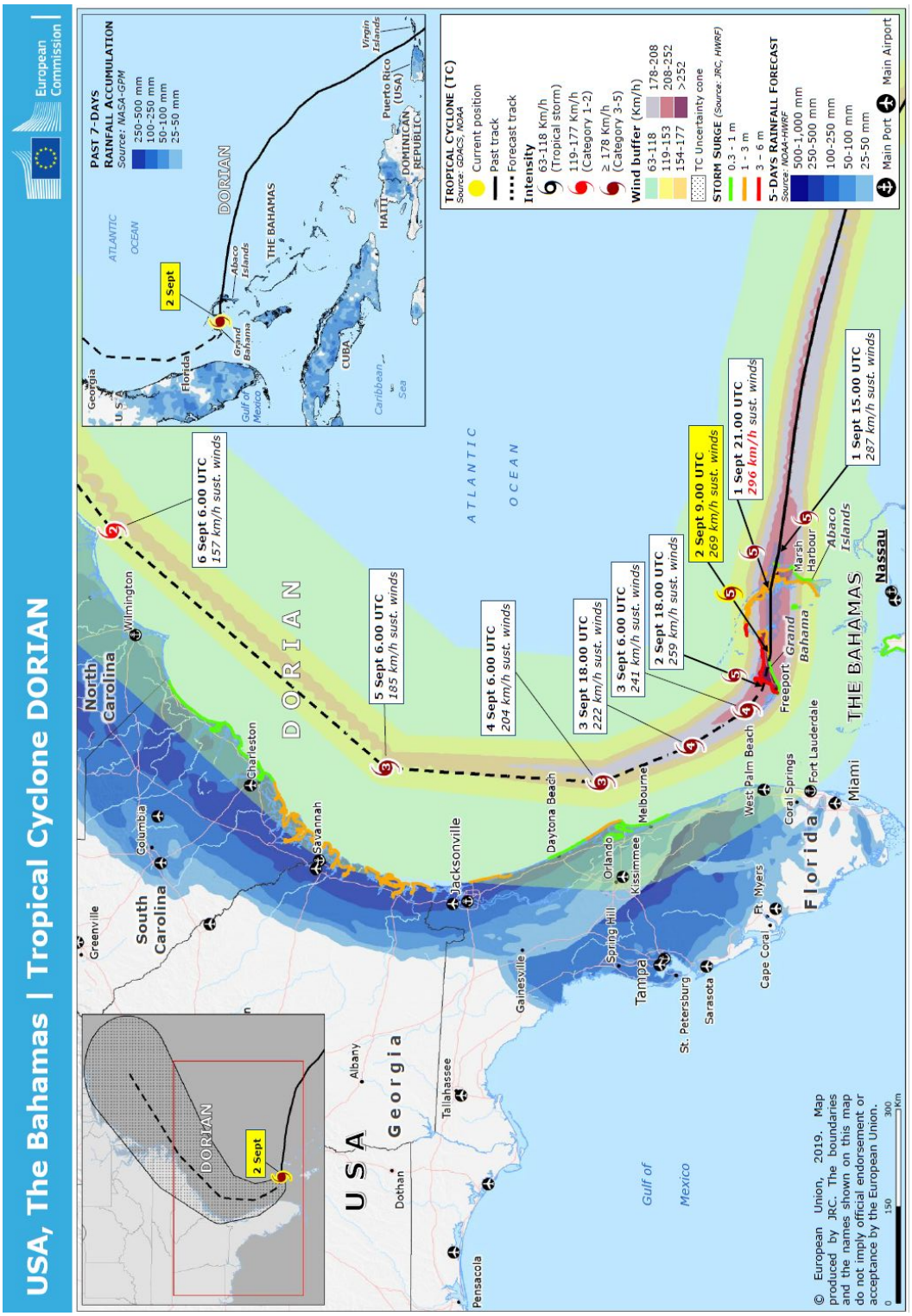


Figure A *- Detailed map on TC DORIAN, as of 2 September 2019*