environmental sciences proceedings

DEVELOPMENT AND TRAJECTORY OF HURRICANE ETA. CASE STUDY USING THE WRF MODEL WITH DYNAMIC UPDATE OF THE SEA SURFACE TEMPERATURE (SST).

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The 2020 Atlantic hurricane season recorded a record of 30 named tropical storms.

It was the sixth consecutive season with above-average stormy activity.

ETA:

- 165 direct deaths
- +100 missing persons

Central America Southern Mexico.

Irregular Trajectory

Unusual Behavior

Cuba → heavy cloudy areas → locally intense rains → gave rise to coastal and river flooding → **25.000 evacuations**

Abstract:

This research aims to describe the synoptic and general circulation environment in which Eta developed using the ERA5 reanalysis; design experiments with the WRF model; and describe, from the numerical outputs, the meteorological conditions that influenced the two analyzed Eta life periods. When analyzing the maps of the ERA5 reanalysis system, a general underestimation of the wind speed during the analyzed periods was identified. The first moment was characterized by a system in the development phase that failed to intensify under the influence of a trough over the southeastern Gulf of Mexico that generated shear conditions that were maintained during the second moment. Through the experiments that were carried out with the WRF-SST and from the numerical outputs, it was possible to describe with greater precision the meteorological conditions that influenced the development, trajectory and intensity changes of Eta.

Keywords: tropical cyclone; Eta; re-analysis system; numerical model.

Introduction

It has been shown that the ocean-atmosphere interaction plays a fundamental role in the weather and climate variability, as well as the importance of considering this relationship in studies for the forecast of storms, wind on the coasts for their use as an energy resource and the forecast of atmospheric phenomena such as tropical cyclones (TC). The use of a dynamic ocean surface temperature introduces improvements in the atmospheric and oceanic representation obtained from models such as the WRF [1]. In addition, the coupling to an ocean model allows a more realistic representation of the ocean thermal field [2][3] as well as a good representation of the ocean and atmospheric processes that occur during a TC [4].

The need to delve into the complex mechanisms and factors that intervened in the genesis and development of this system, as well as the use of numerical weather modeling with dynamic updating of the sea surface temperature (SST) for its understanding, motivated the realization of this research, which aims to: describe the synoptic and general circulation environment in which Eta was developed using the ERA5 reanalysis; design experiments with the WRF model, for the simulation of the case study with greater spatial and temporal resolution; describe, based on the numerical outputs, the meteorological conditions that influenced the development and the change in intensity that Eta experienced between November 7 and 11, 2020, which will be divided into two moments.

Materials and Methods

WRF

ARW ⇨ Dynamic Core

4.2.2

Initialized with GFS-analysis

Atmosferic Model Settings

=

SisPI

9 km of resolution

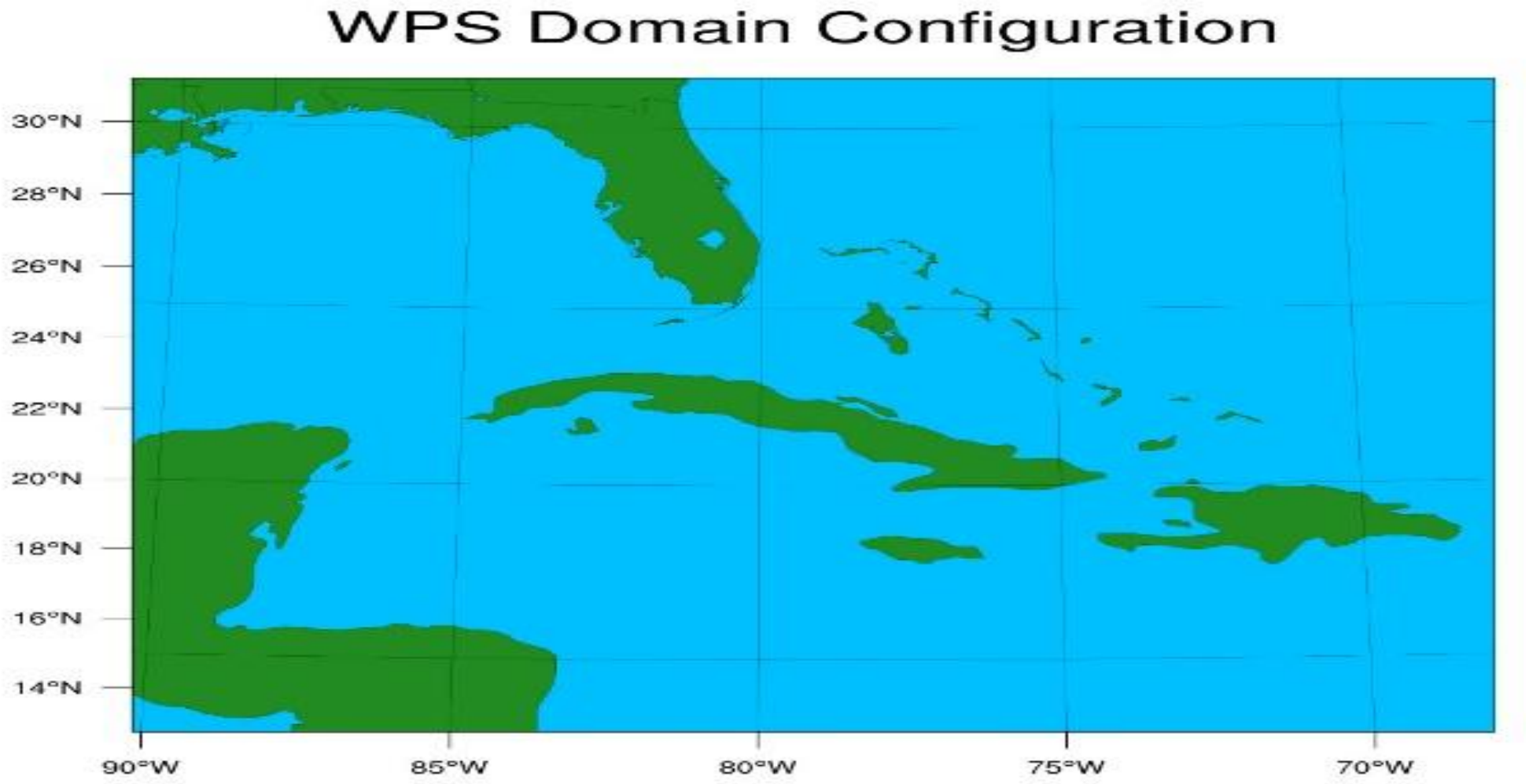
ERA5

Global Climate Monitoring Tool

Reanalisys of the Planet's Global Climate

- ✓ Best possible understanding of past climate
- ✓ What happened during a particular weather event and why
- ✓ Relate current and past weather events

Simulation Domain used in the WRF model



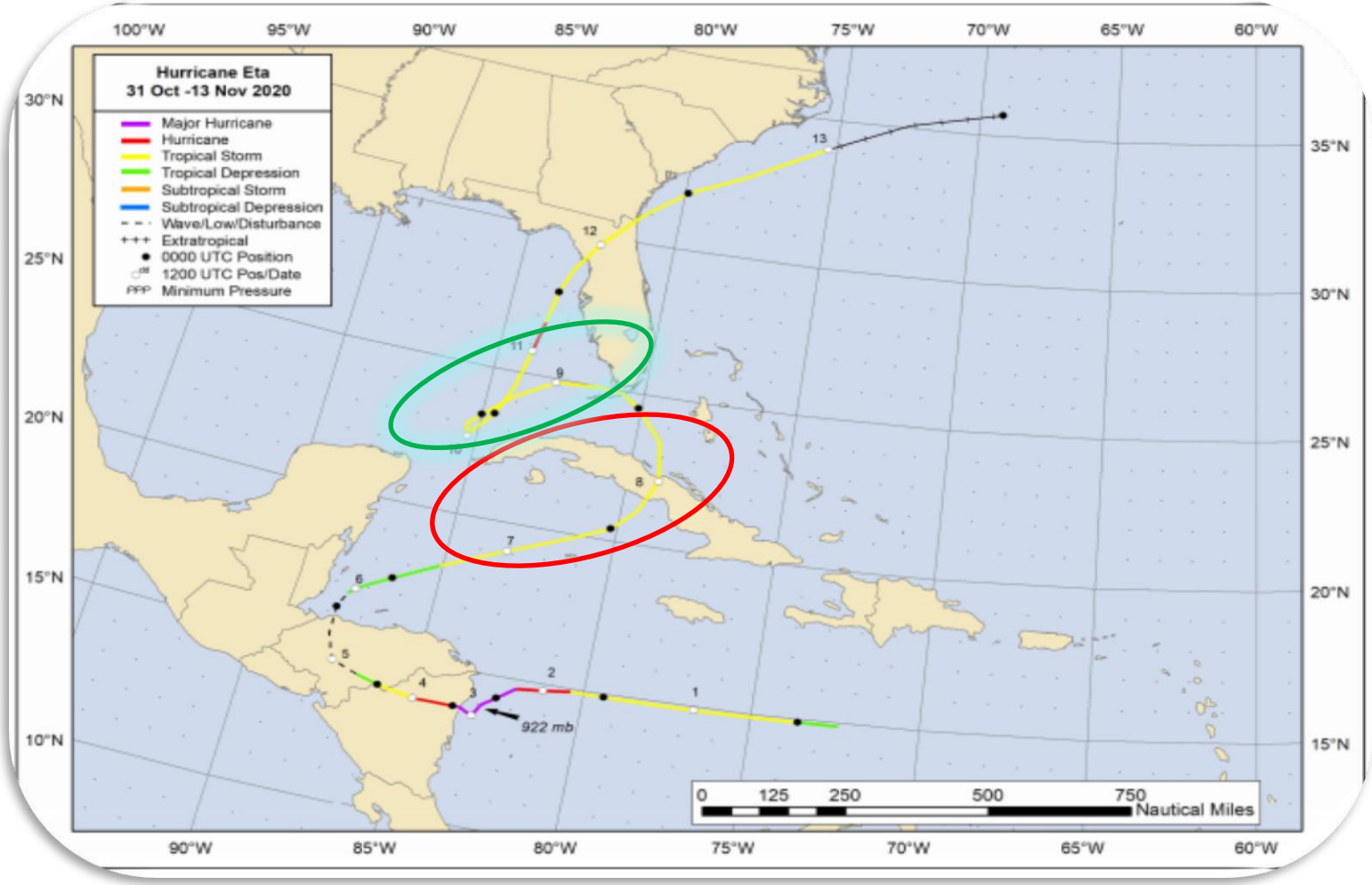
Results and Discussion

ETA:

Moments of interest:

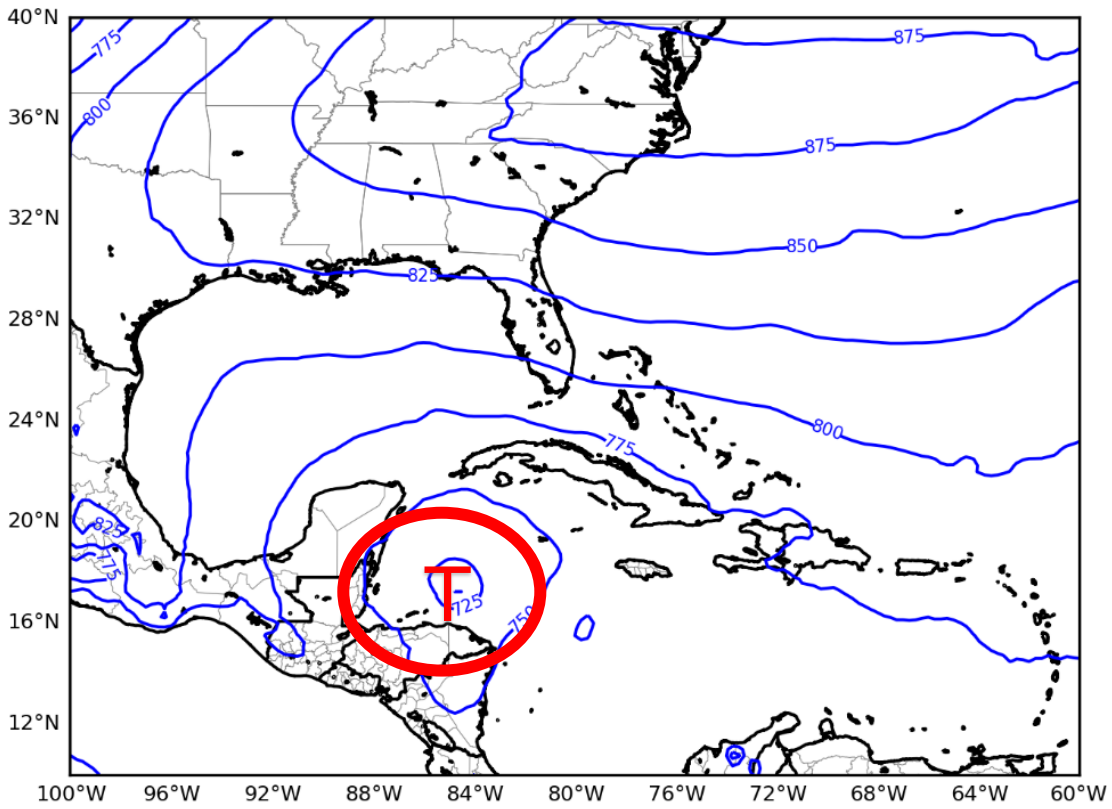
✓ First moment:
November 7 to 8, 2020

✓ Second moment:
November 9 to 11, 2020

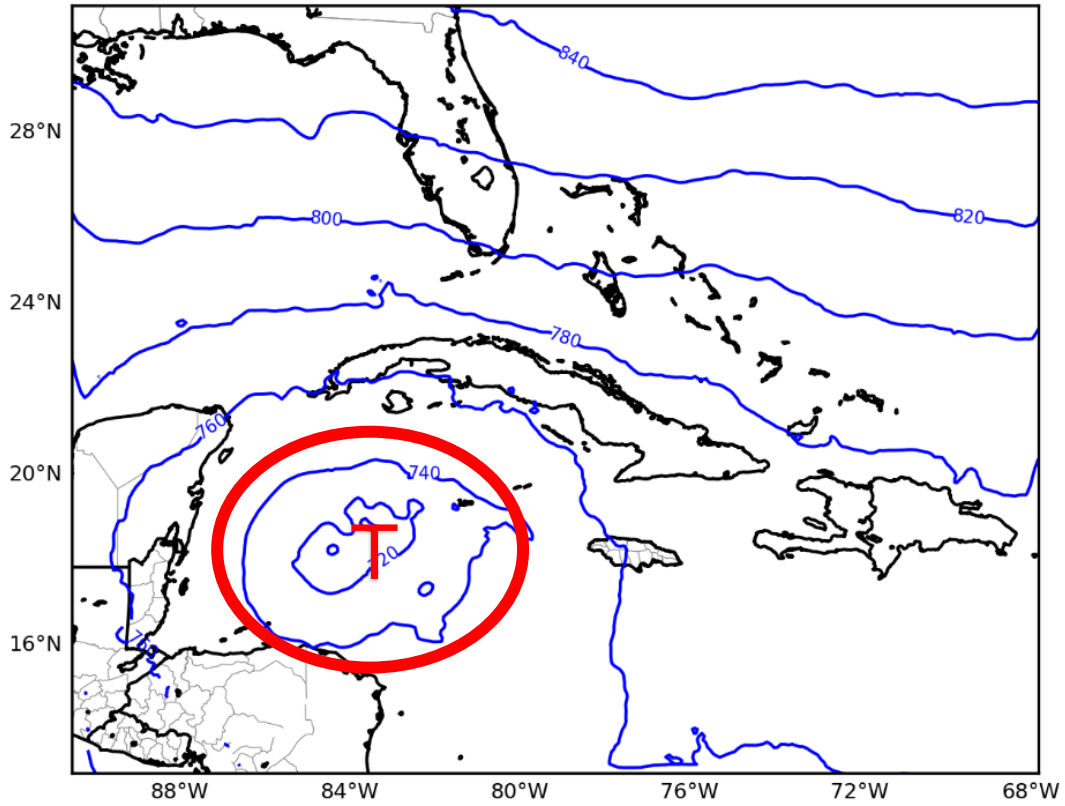


First moment: November 7 to 8, 2020

ERA5



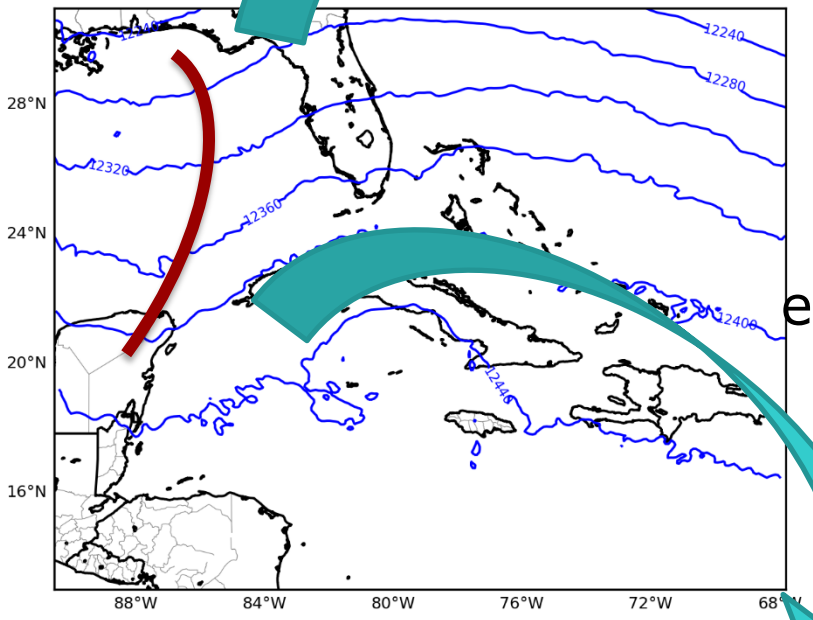
WRF-SST



06:00 UTC November 7, 925hPa

15:00 UTC November 7, 200hPa

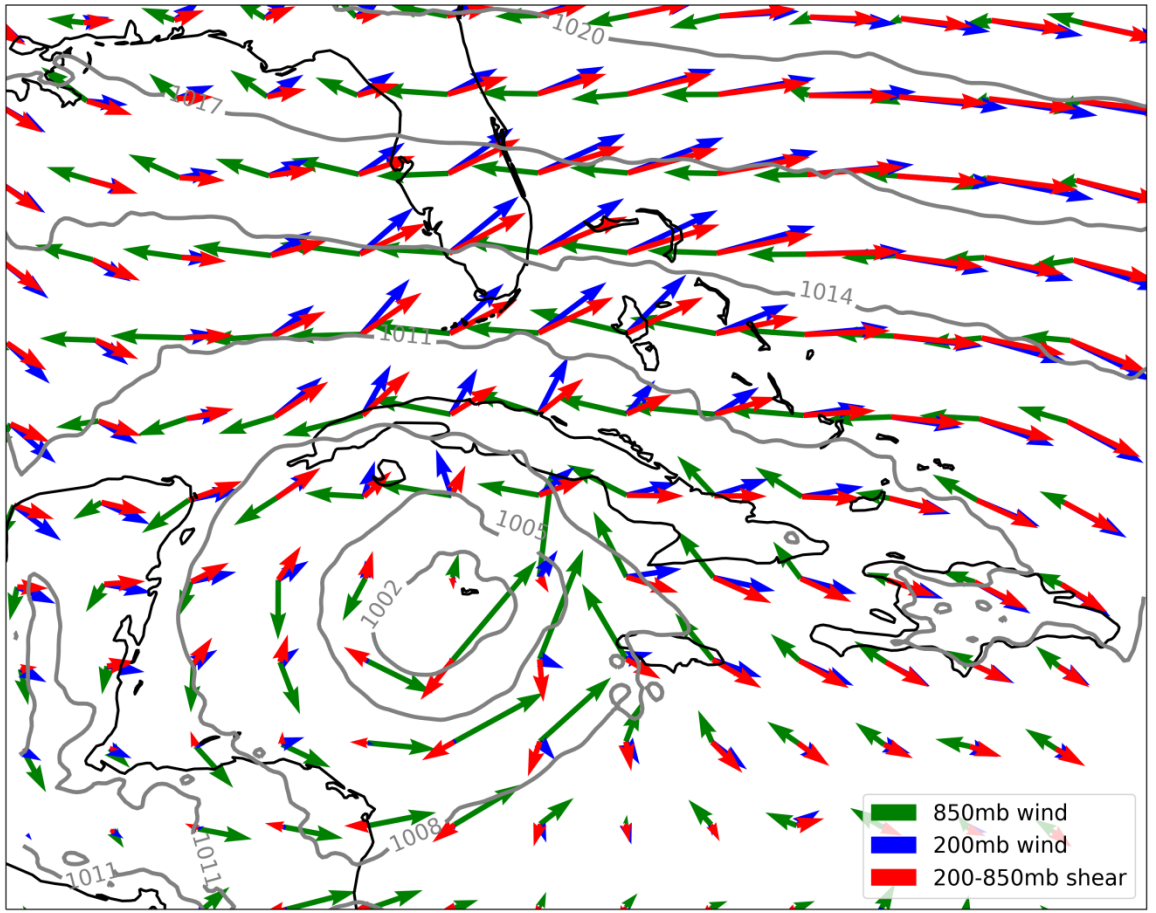
WRF-SST



Generated a shealed environment on Eta

Introduced a third quadrant flow

Induced its northeast shift

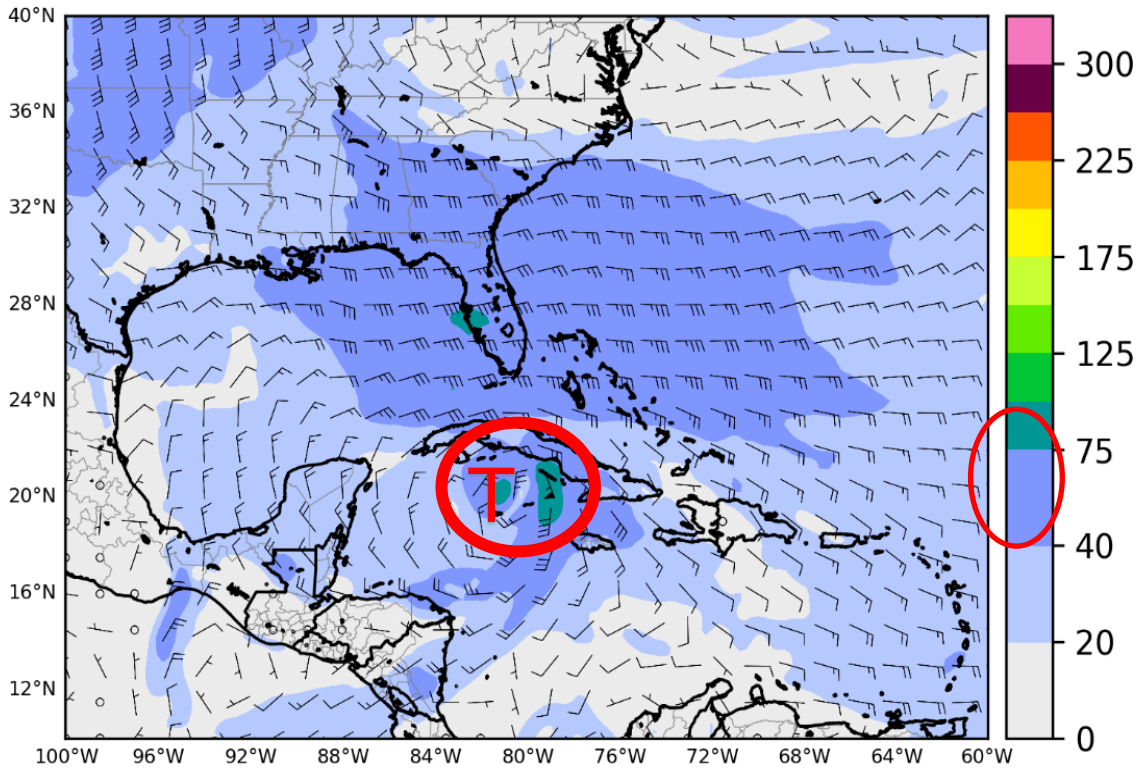


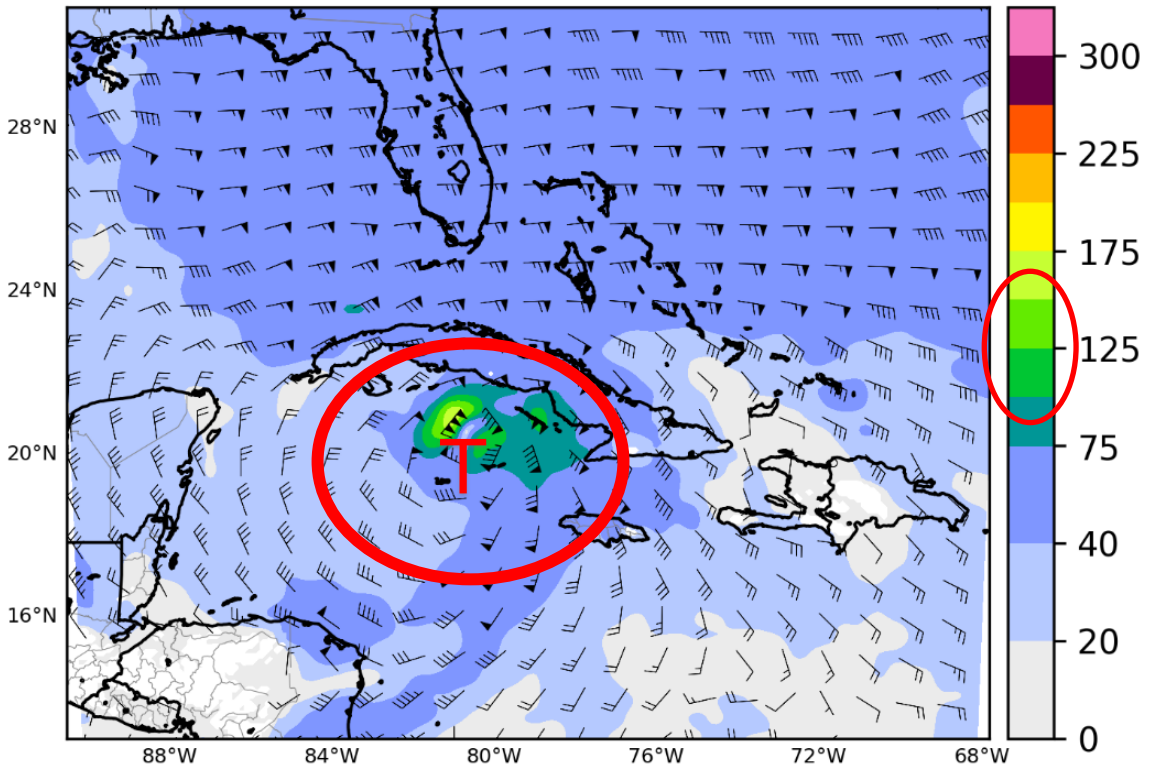
ERA5

WRF-SST

40-75 km/h

80-150 km/h

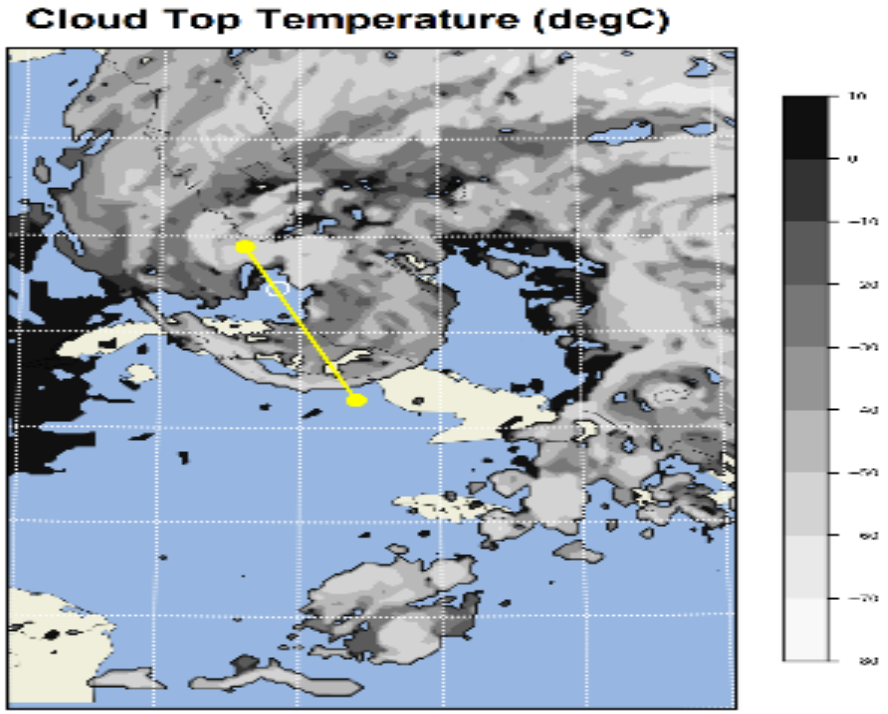


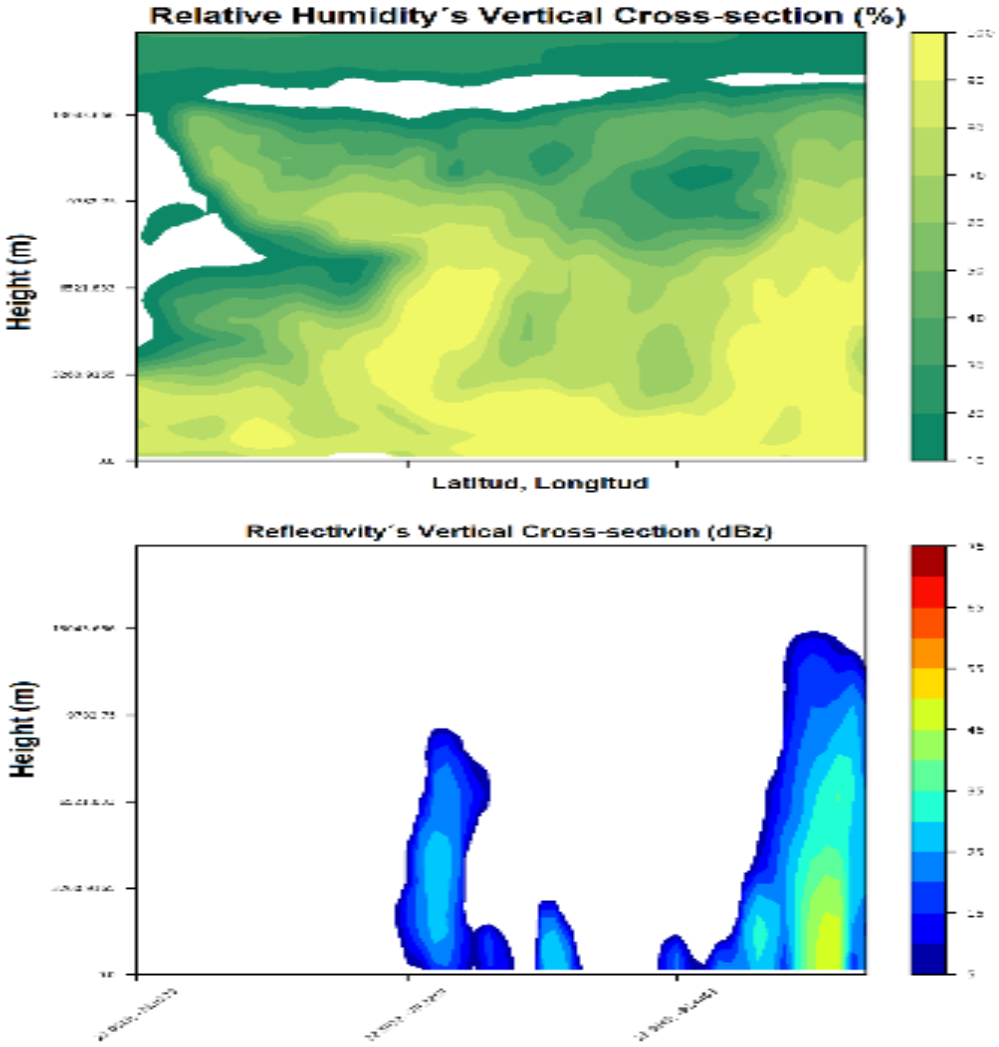


00:00 UTC November 8, 925hPa

WRF-SST

Relative Humidity's Vertical Cross-section and Reflectivity

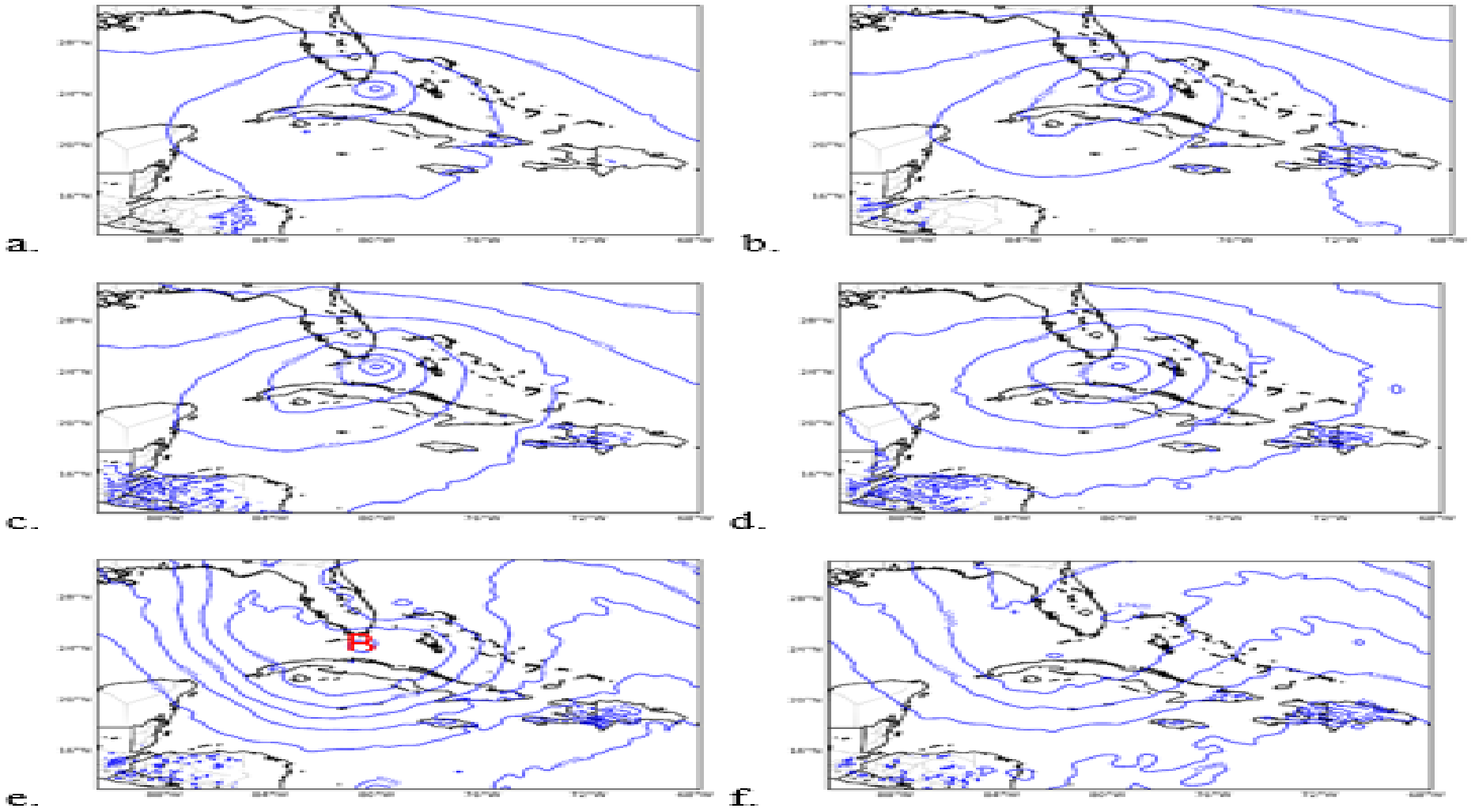




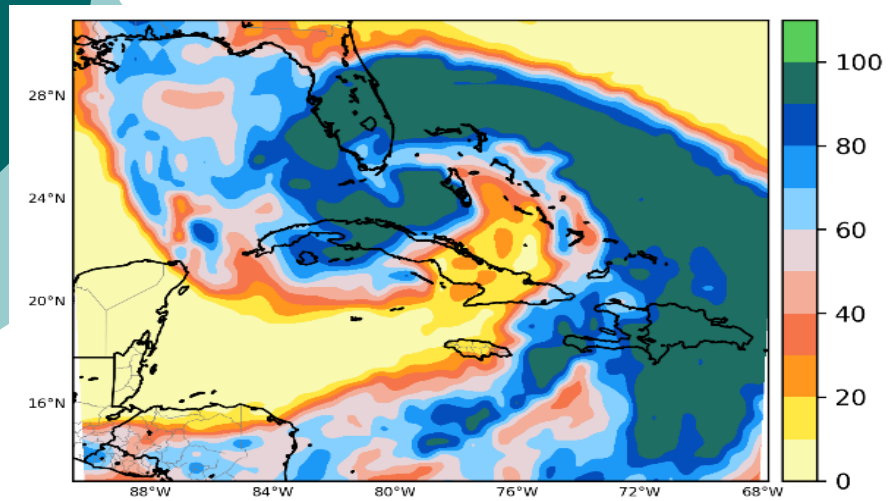
21:00 UTC of November 8

Second moment: November 9 to 11, 2020

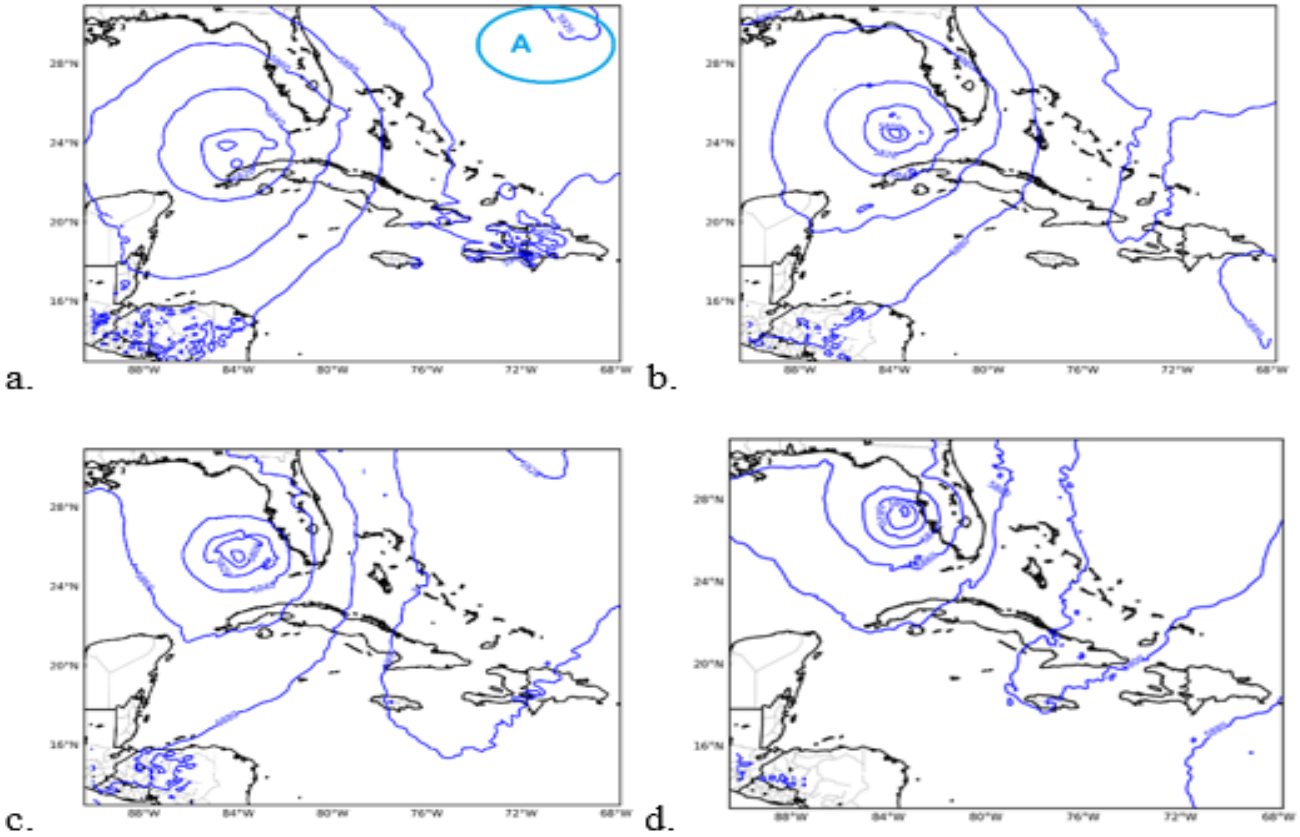
WRF-SST Geopotential Height Maps of 9 November at 00:00 UTC in the levels: a) 925hPa, b) 825hPa, c) 700hPa, d) 500hPa, e) 300hPa y f) 200hPa.



Second moment: November 9 to 11, 2020

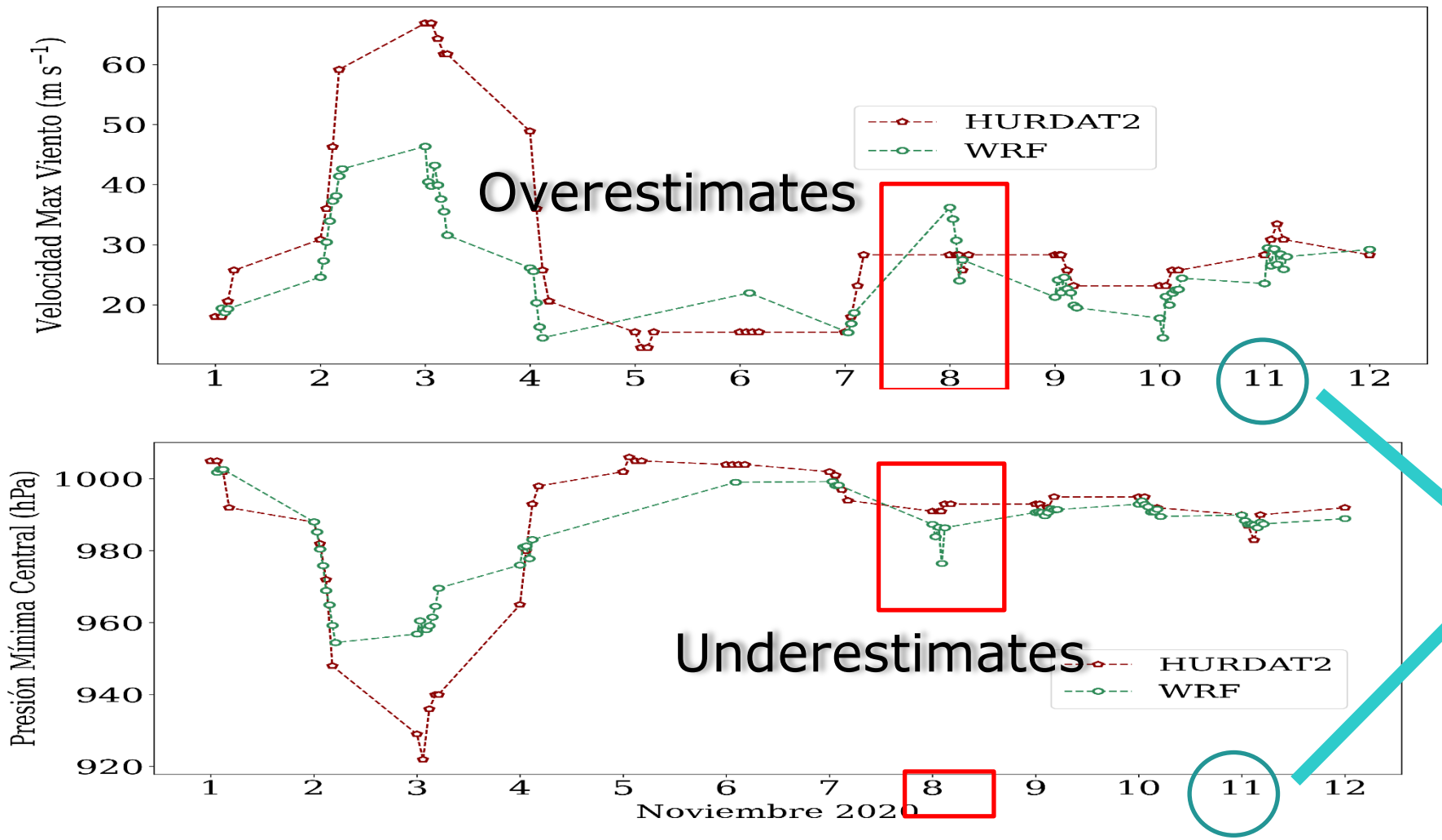


Relative Humidity Map of November 9 at 00:00 UTC in 500hPa level.

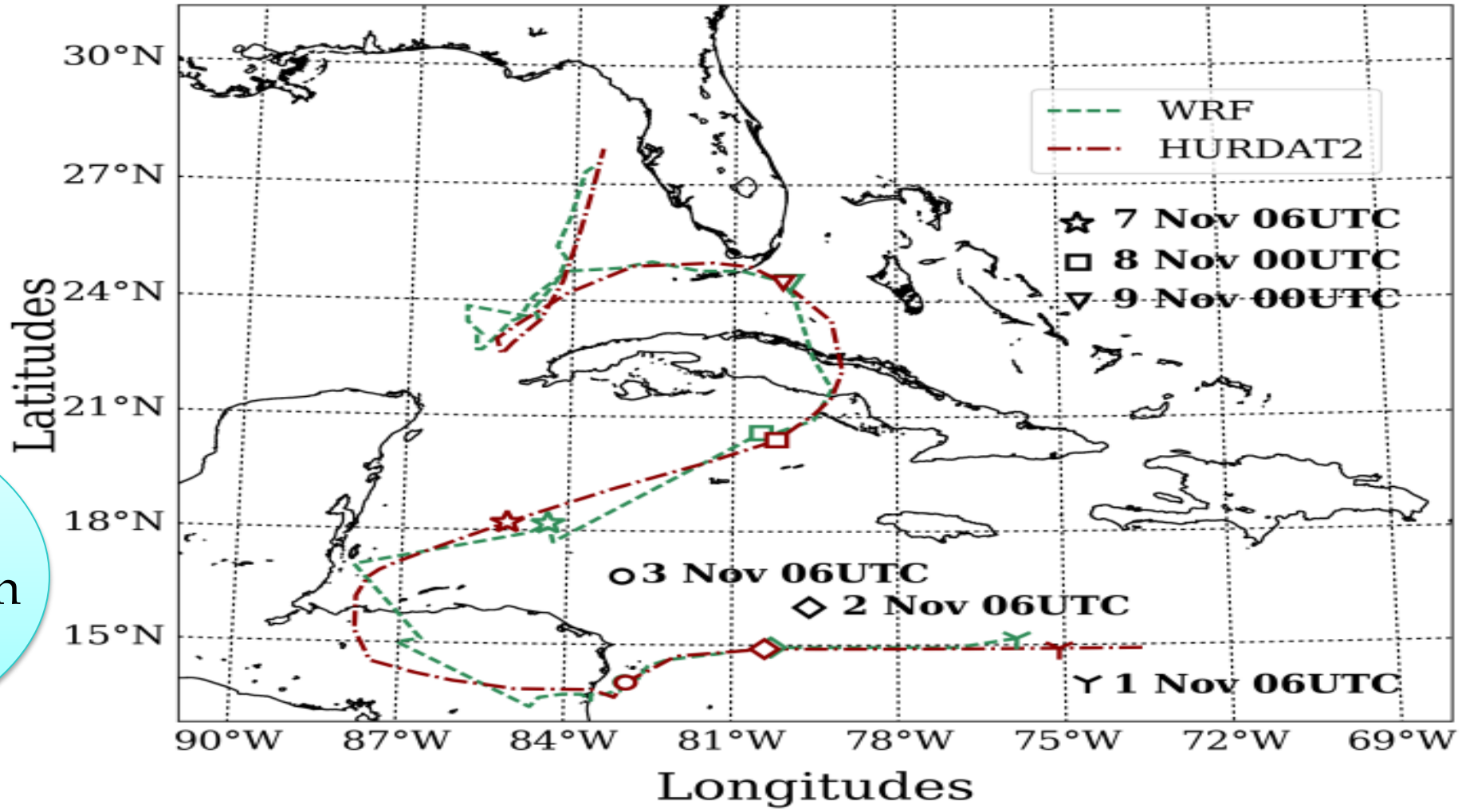


Geopotential Height Maps of November 11, 2020 in 500hPa level at: a) 00:00 UTC, b) 06:00 UTC, c) 12:00 UTC y d) 21:00 UTC.

WRF-SST


Velocidad Max Viento (m s^{-1})
60
50
40
30
20
HURDAT2
WRF
Overestimates
1
2
3
4
5
6
7
8
9
10
11
12
Presión Mínima Central (hPa)
1000
980
960
940
920
Underestimates
HURDAT2
WRF
Noviembre 2020
The smallest errors

WRF-SST



The system made a very good estimation in general

Conclusions

1. When analyzing the maps of the ERA5 reanalysis system, a general underestimation of wind speed during the analyzed periods. The first moment was characterized by a system in the development phase that failed to intensify under the influence of a trough over the southeastern Gulf of Mexico that generated a sheared environment. These conditions were maintained during the second moment, when the organism described an erratic trajectory due to the fact that it was under the influence of weak directing currents, until it entered the flow of a ridge that led it to re-direct its trajectory towards the north.

2. Through the experiments that were carried out with the WRF-SST and from the numerical out-puts, it was possible to describe with greater precision the meteorological conditions that influenced the development, trajectory and intensity changes of Eta.

Conclusions

3. With the WRF-SST flow maps, an improvement was observed in terms of the estimation of wind speed and geopotential found in the ERA5 maps during the study periods. It was possible to specify, through the vertical cross sections, the behavior of the vertical wind speed, the reflectivity and the relative humidity in the vertical that allowed one to have a more realistic vision of the evolution of Eta.

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MDPI

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Thanks a lot!

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