Evaluating the impact of Global Hawk observations to HWRF forecasts

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1. Objective

This project is motivated to understand the impact of observations from the Global Hawk Unmanned Aircraft System to forecasts of Atlantic tropical cyclones using the operational 2015 HWRF model. This research is a key component of the SHOUT project (Sensing Hazards with Operational Unmanned Systems) which aims to evaluate and test how targeted observations from aircraft over oceanic regions could improve model forecast of high impact events including tropical cyclones and winter storms.

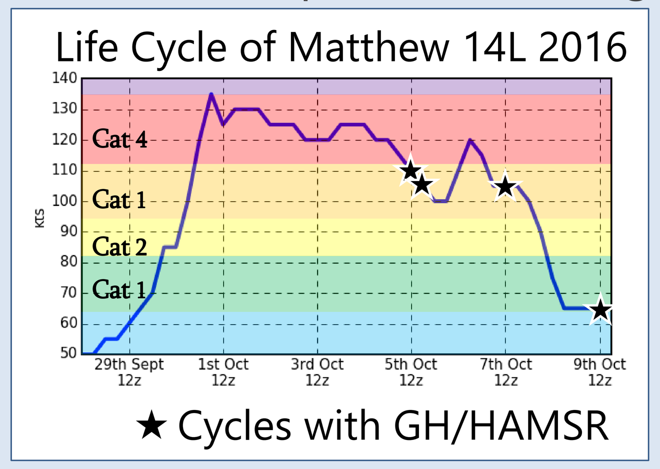
2. Hurricane Matthew Flight Campaign 2016

Global Hawk completed 3 flights in and around Hurricane Matthew to observe both the inner and outer storm environment on 5th, 7th, 9th October 2016. Here, the results of an Observation System Experiment (OSE) study is presented, where forecasts of Matthew are performed using HWRF for:

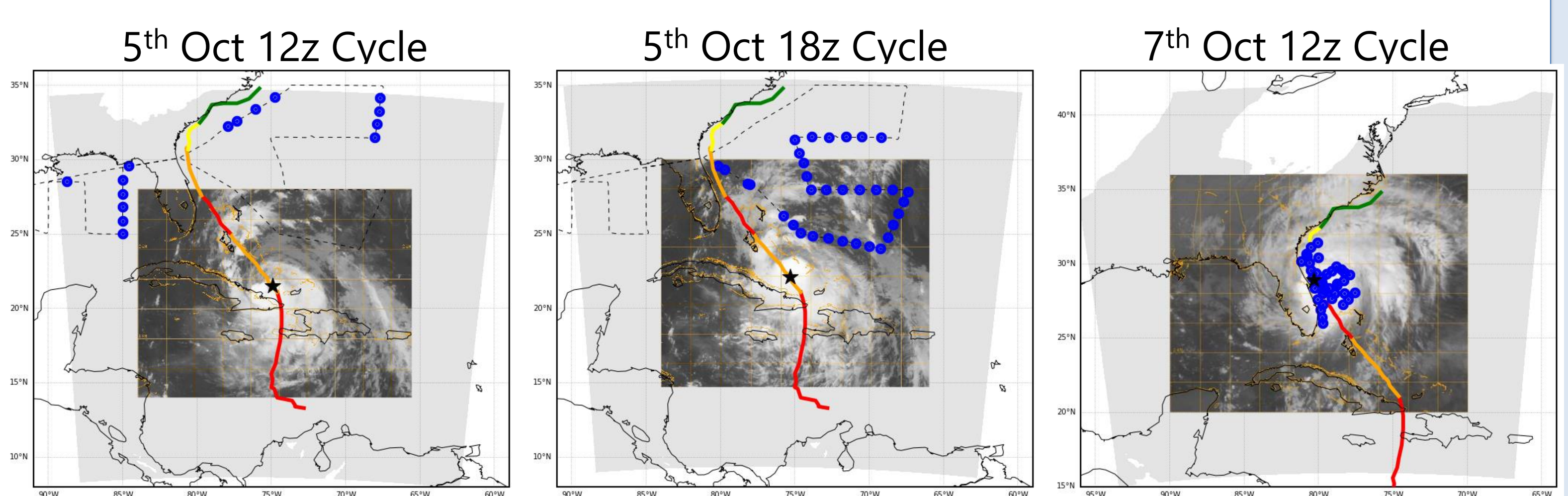
1) *CTL* – Default 2015 Operational Setting

2) *DROPS* – *CTL* + Assimilation of Global Hawk Dropsondes

3) *HAMSR* – CTL + Assimilation of HAMSR Retrievals



Dropsondes Launch Locations Matthew 14L 2016



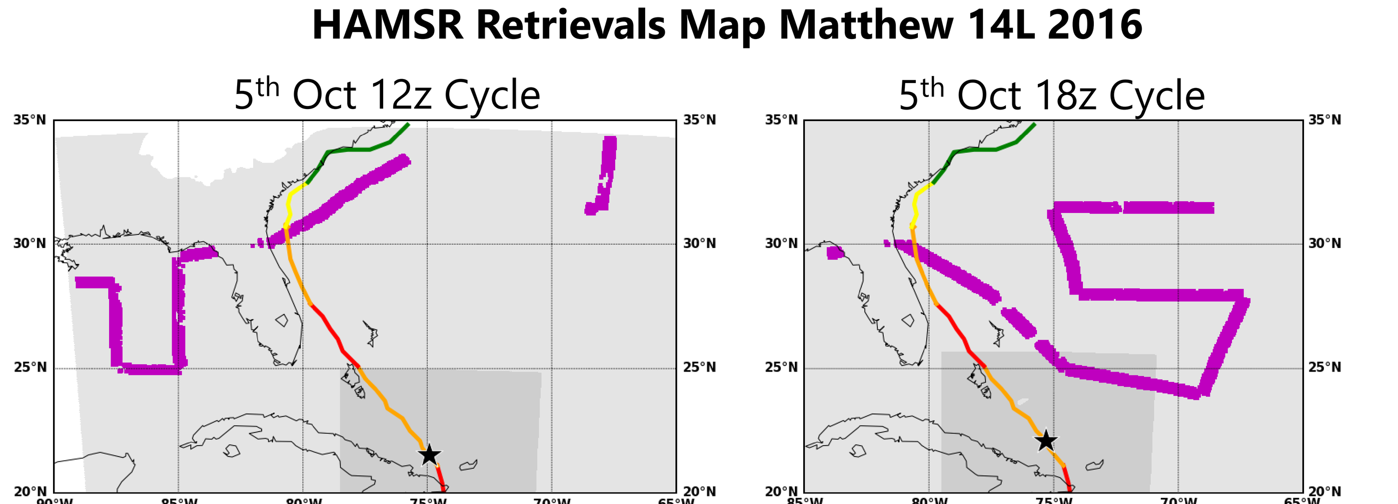
# of Observations Assimilated		
HWRF domain	d02	d03
T, UV	≈520	0
Humidity	≈300	0

# of Observations Assimilated		
HWRF domain	d02	d03
T, UV	≈1350	≈800
Humidity	≈830	≈500

# of Observations Assimilated		
HWRF domain	d02	d03
T, UV	≈1360	≈2080
Humidity	≈990	≈1170

Figure 1: Maps showing flight paths (dashed line), dropsonde launch locations (blue circles), NHC observed track (line) and storm center (black star) for the 5th, 7th and 9th flights. The grey boxes show the extent of HWRF domains d02 (6km resolution - light grey) and d03 (2km resolution - grey) where the data assimilation is performed.

HAMSR Retrievals Map Matthew 14L 2016



Number of Observations Assimilated		
HWRF domain	d02	d03
Temperature	≈158,000	0
Humidity	≈158,000	0

Number of Observations Assimilated		
HWRF domain	d02	d03
Temperature	≈170,000	≈300,000
Humidity	≈170,000	≈300,000

Figure 2: Maps showing location of HAMSR retrievals for the 10/05 12z and 18z cycles (purple squares), NHC observed track (line), storm center (star) and HWRF domains d02 and d03.

NASA Global Hawk

AVAPS

The Advanced Vertical Atmospheric Profiling System is capable of deploying up to 88 dropsondes at altitudes up to 65,000ft, over a 28 hour flight time, providing high vertical resolution measurements of temperature, pressure, humidity and winds

HAMSR

The High Altitude MMIC Sounding Radiometer is a microwave temperature and humidity sounding instrument

3. Impact to HWRF track and intensity forecasts

Figure 3 shows averaged track and intensity errors (compared to NHC tropical cyclone reports) from *DROPS* and *CTL* forecasts for cycles where GH dropsondes/HAMSR were available. *DROPS* and *HAMSR* both reduce track error compared to *CTL* after approx. 2 days into the forecast (Fig 3a), with the former producing the better performance and an improvement in track forecast of approx. 30% (Fig3b). The impact to intensity errors (10m max. wind speed and MSLP – Figs 3C-F) show more mixed results but with indications that both *DROPS* and *HAMSR* may lead to an improvement in intensity forecasts at longer lead times. *HAMSR* forecasts in particular showed good improvement in MSLP forecasts during this forecast period (Fig 3C-D).

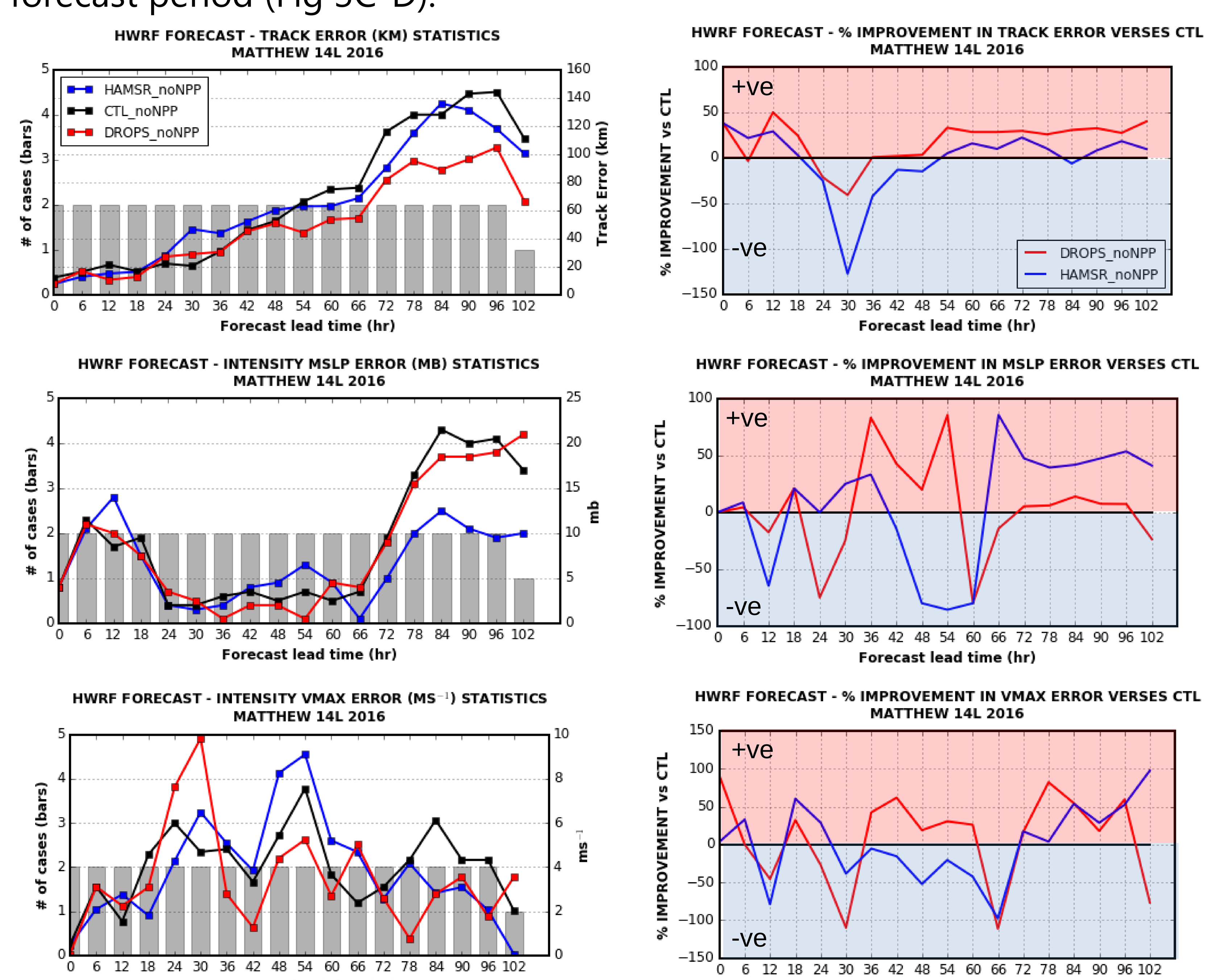


Figure 3: Track and intensity error statistics from *CTL*, *DROPS* and *HAMSR* forecasts, averaged at each forecast lead time over cycles where GH observations were available. National Hurricane Center Tropical Cyclone reports were used for verification of forecast metrics

4. Rainfall Impacts

Comparisons of the accumulated rainfall totals from the 10/05 18z forecasts to observed rainfall totals (ECMWF) revealed that the good improvement to the track forecast from *DROPS* over *CTL* led to improvements in the forecast of accumulated rainfall over southeast corner of US, including North and South Carolina, which received some of the highest recorded amounts.

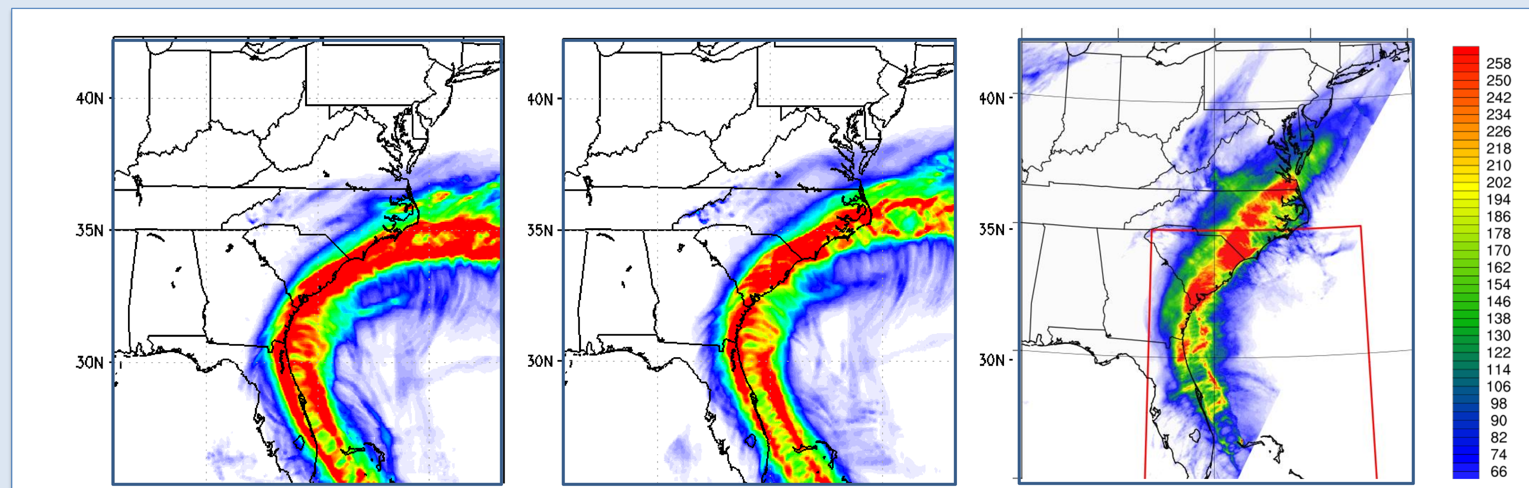


Figure 4: Forecast along-track accumulated rainfall totals (mm) from *CTL* (left), *DROPS* (middle) from forecasts initiated on 5th October 12z and observed rainfall totals taken from ??.

5. Structure and Analysis

Averaged increments of temperature and humidity show a general increase in temperature and moistening of the PBL over the outer storm environment as a direct impact from the assimilation of the dropsondes (Fig 6). Oher key differences of the analysis include stronger mid-level radial wind field from *HAMSR* compared to *DROPS* and *CTL*

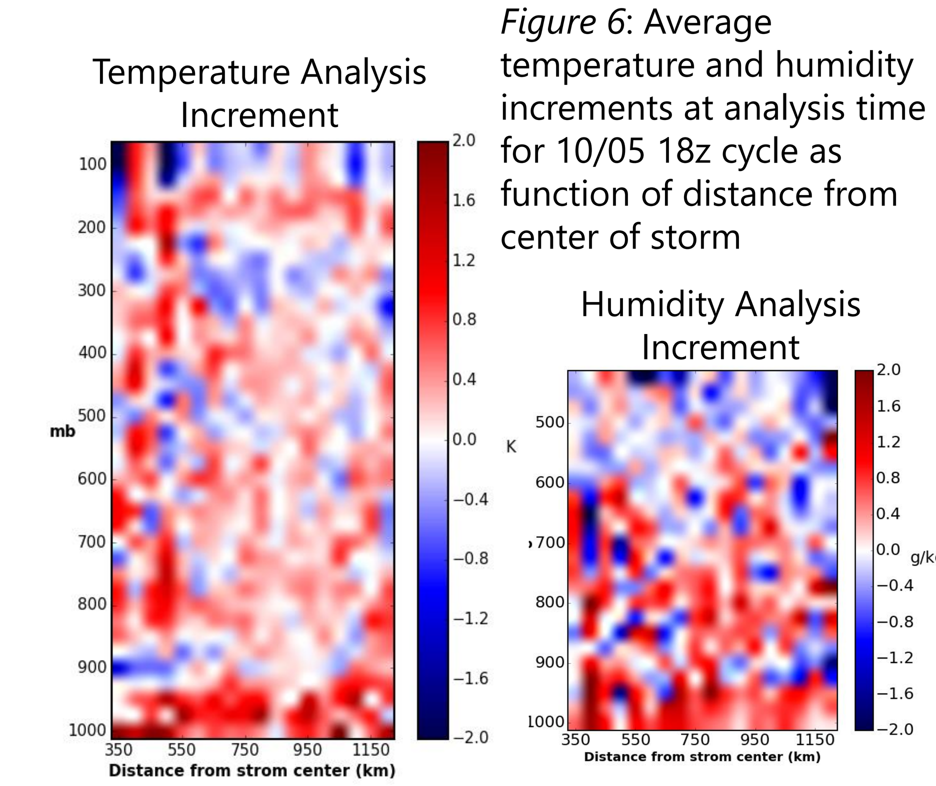


Figure 6: Average temperature and humidity increments at analysis time for 10/05 18z cycle as function of distance from center of storm

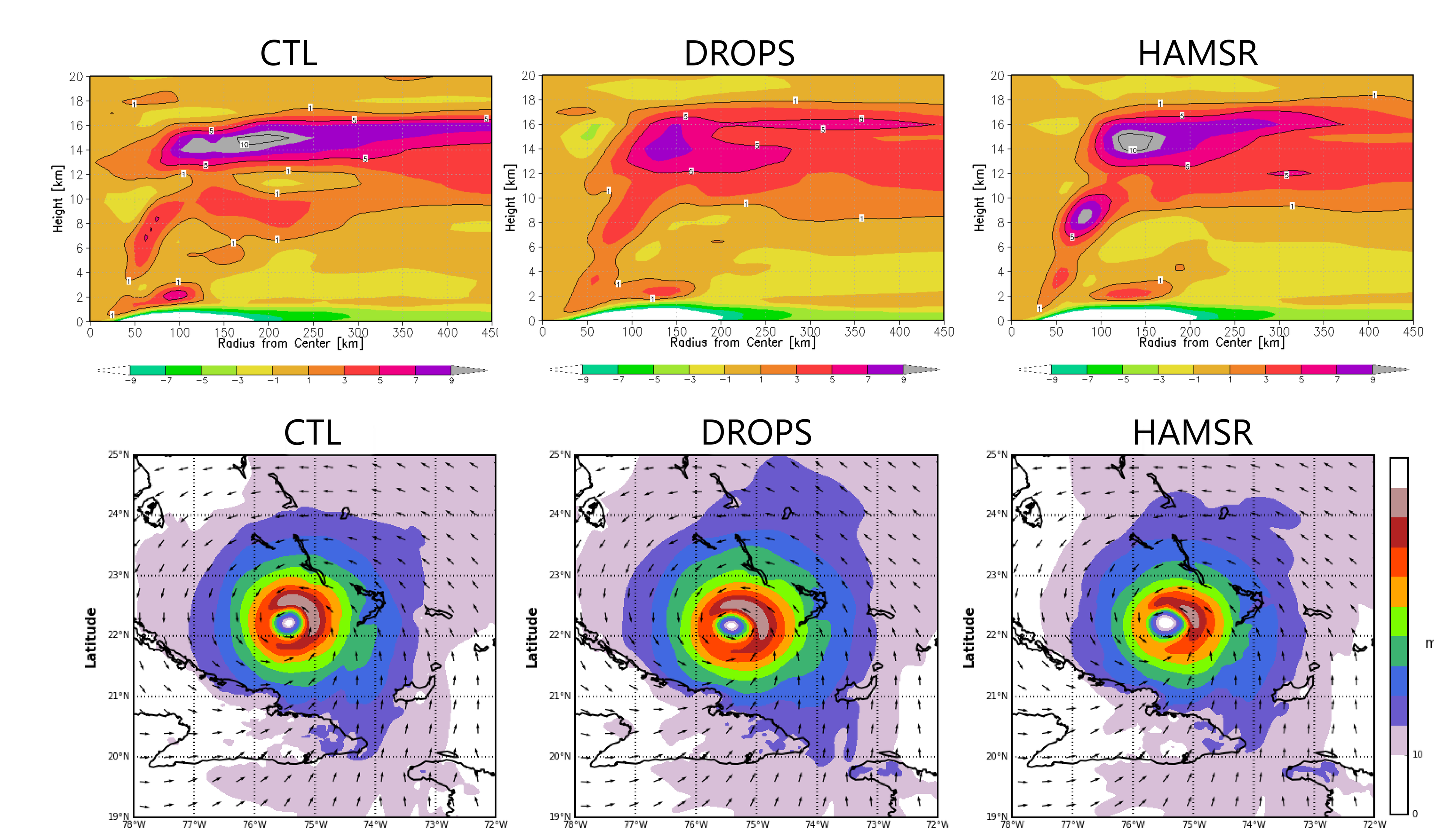


Figure 8: *Top row*: Azimuthally averaged radial wind for *CTL, DROPS, HAMSR* for 10/05 18z cycle. *Bottom row*: Surface wind at analysis time for 10/05 18z.

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