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.


Global Hawk completed 3 flights in and around Hurricane Matthew to observe both the inner and outer storm environment on 5\textsuperscript{th}, 7\textsuperscript{th}, and 9\textsuperscript{th} 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

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\% (Fig 3b). 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. HWRF forecasts in particular showed good improvement in MSLP forecasts during this forecast period (Fig 3c-D).

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.

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). Other key differences of the analysis include stronger mid-level radial wind field from HAMSR compared to DROPS and CTL.

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

Figure 5: Hurricane Matthew Flight Campaign launch locations for Global Hawk (purple) and University of Miami HAMSR (orange) retrieval locations

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

Figure 7: Maps showing flight paths (dashed line), dropsonde launch locations (blue circles), NHC observed track (line) and storm center (black star) for the 5\textsuperscript{th} and 9\textsuperscript{th} 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.

Figure 8: Top row: Azimuthally averaged radial wind for CTL, DROPS, and HAMSR for 10/05 18z cycle. Bottom row: Surface wind at analysis time for 10/06 18z.

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