Operational Impact of Data Collected from the Global Hawk Unmanned Aircraft During SHOUT

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Discussion

• SHOUT Objectives
• SHOUT Campaign
• Real-Time Data Utilization
• Forecast Impacts
• Conclusions

Photo Credit: Steve Crowell, Northrop Grumman
SHOUT Objectives

Overall Goal
- Demonstrate and test prototype UAS concept of operations that could be used to mitigate the risk of diminished high impact weather forecasts and warnings in the case of polar-orbiting satellite observing gaps

Objective 1: UAS Data Impact
- Conduct data impact studies
- Observing System Experiments (OSE) using data from UAS field missions
- Observing System Simulation Experiments (OSSE) using simulated UAS data

Objective 2: Cost-Operational Benefit Analysis
- Evaluate cost and operational benefit through detailed analysis of life-cycle operational costs and constraints
NOAA SHOUT Project Assets

Global Hawk Aircraft

- Flight Level: ~55-65,000 ft
- Duration: ~24 hr
- Flight Frequency
  - 1x per 48 hr (every other day)
  - 3 consecutive flights
  - 7 day max >> hard down
- Range: 8-10,000 nm
- Payload: 1,500+ lbs
- Deployment Sites
  - NASA Wallops Flight Facility (Wallops Island, VA)
  - NASA Armstrong Flight Research Facility (Edwards AFB, CA)
- Global Hawk Operations Center (GHOC) mission support
  - 3 shifts per mission
Global Hawk SHOUT Instrumentation

**Airborne Vertical Atmospheric Profiling System (AVAPS)**

*PI:* Terry Hack, NCAR / Gary Wick, NOAA  
*Measurements:*  
- temperature, pressure, wind, humidity profiles  
- 90 drop sondes per flight  
*Resolution:*  
- ~2.5 m (winds), ~5 m (PTH)

**High Altitude Monolithic Microwave Integrated Circuit (MMIC) Sounding Radiometer (HAMSR)**

*PI:* Dr. Bjorn Lambrigtsen, JPL  
*Measurements:*  
- Microwave AMSU-like sounder  
- 25 spectral channels in 3 bands (50-60, 118, & 183 GHz)  
- 3-D distribution of temperature, water vapor, & cloud liquid water  
*Resolution:*  
- 2 km vertical; 2 km horizontal (nadir)  
- 40 km wide swath

**High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)**

*PI:* Dr. Gerald Heymsfield, NASA GSFC  
*Measurements:*  
- Dual-frequency (Ka- & Ku-band), dual beam, conical scanning Doppler radar  
- 3-D winds, precipitation, & ocean vector winds  
*Resolution:*  
- 60 m vertical, 1 km horizontal;
SHOUT Field Campaigns

Hurricanes 2015
- 3 missions/2 named storms
- 1st NOAA-operational assimilation of Global Hawk dropsondes

El Niño Rapid Response (ENRR) 2016
- 3 atmospheric river and winter storm missions
- Demonstrated ability to plan and deploy on short notice

Hurricane Rapid Response (HRR) 2016
- 9 missions/4 named TCs
- Shift to operational deployment model
- Collaborations: NOAA IFEX, ONR TCI, & NAWDEX

NASA EPOCH 2017
- 1st operational GPS dropsonde assimilation in GFS
SHOUT Real-Time Data

• Flexibility modifying Global Hawk flight tracks
  ➢ ATC coordination with ~30 min notice

• High bandwidth real-time GH data access
  ➢ GPS dropsondes, HAMSR, & HIWRAP

• Operational use of Global Hawk dropsonde data
  ➢ GPS dropsonde data routinely QCed and transmitted to the GTS
  ➢ Used in real-time by forecasters at NOAA NHC
  ➢ Real-time assimilation in operational models (e.g., GFS, HWRF, ECMWF)
2016 Hurricane Gaston

NOAA NHC Tropical Cyclone Report

- 25 Aug: “Operationally, Gaston was analyzed as a 60-kt tropical storm until dropwindsonde data from a NASA Global Hawk unmanned aircraft mission indicated that the tropical cyclone was a hurricane.”

2016 Tropical Depression Nine (Hurricane Hermine mission)

NOAA NHC Discussion #7

- 30 Aug: “A dropsonde from the Global Hawk reported 33 kt surface winds, but the mean-layer wind over the lowest 150 m support winds closer to 30 kt. A very recent center drop from the unmanned aircraft indicate that the minimum pressure is 1003 mb.”
Adaptive Aircraft Sampling (GPS Dropsondes)
2016 Hurricane Gaston

Forecast Uncertainty vs. Sensitivity

• Uncertainty: where is there uncertainty in the model forecast?
• Sensitivity: where is the model more vs less sensitive to observations?
• Where do you sample and will the model be sensitive to your added data?

ECMWF 50 member ensemble track forecasts

Adaptive Aircraft Sampling (GPS Dropsondes)

2016 Hurricane Gaston
SHOUT Forecast Impact Studies

• **NOAA/OAR/AOML/HRD**
  - Regional hurricane modeling
  - HWRF with multiple data assimilation schemes
  - Dropsonde impacts and initial results for remote sensors

• **NOAA/OAR/ESRL/GSD**
  - Global model impacts for hurricanes and landfalling winter storms
  - GFS with 2015 operational configuration
  - Dropsonde impacts both with and without a satellite gap

• **Collaboration with NOAA/NWS/NCEP/EMC**
  - Operational GFS and HWRF with full observing system
  - Dropsonde impacts only
EMC Results – GFS Model
Atlantic TCs 2014-2016

- Dropsonde impact on operational 2017 GFS Atlantic forecasts for Atlantic 2014-2016
- Peak improvement ~15% at 72 h
- Statistically significant improvements at 72 and 96 h

Results courtesy Jason Sippel and Vijay Tallapragada, NOAA/NCEP/EMC
EMC Results – GFS Model
2016 Hurricane Hermine

• Dropsonde impact on operational 2017 GFS forecasts of Hurricane Hermine

• Higher track uncertainty in spite of extensive reconnaissance from C-130 and P-3 (no G-IV).

• Large skill improvements with addition of Global Hawk GPS dropsondes

Results courtesy Jason Sippel and Vijay Tallapragada, NOAA/NCEP/EMC
EMC Results – HWRF Model
Atlantic TCs 2016

- Dropsonde impact on operational 2017 HWRF with new assimilation system
- Results also incorporate retrospective GFS boundary impacts
- Significant track and intensity improvements at 72 and 96 h

Results courtesy Jason Sippel and Vijay Tallapragada, NOAA/NCEP/EMC
Conclusions

• SHOUT demonstrated the potential utility of Global Hawk observations for high-impact weather forecast improvement

• Three successful SHOUT field campaigns (2015-2016)
  ➢ 1 coordinated NOAA UAS/NASA EPOCH field campaign (2017)

• Streamlined field operations have demonstrated operational applications for UAS platforms like the Global Hawk

• Operational utility (GPS dropsondes)
  ➢ real-time data utilized by forecasters at NHC
  ➢ operationally assimilated into NWP forecast models (e.g., GFS, HWRF)
  ➢ positive forecast impacts
## Tropical Cyclone SHOUT Data Impact Summary

### Global Hawk Dropsonde Impact on 96-hour Hurricane Track Forecasts (% Improvement)

<table>
<thead>
<tr>
<th>Model</th>
<th>All Observations</th>
<th>Satellite Gap</th>
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<tbody>
<tr>
<td></td>
<td>Multi Storm</td>
<td>Matthew 16</td>
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<tr>
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