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**

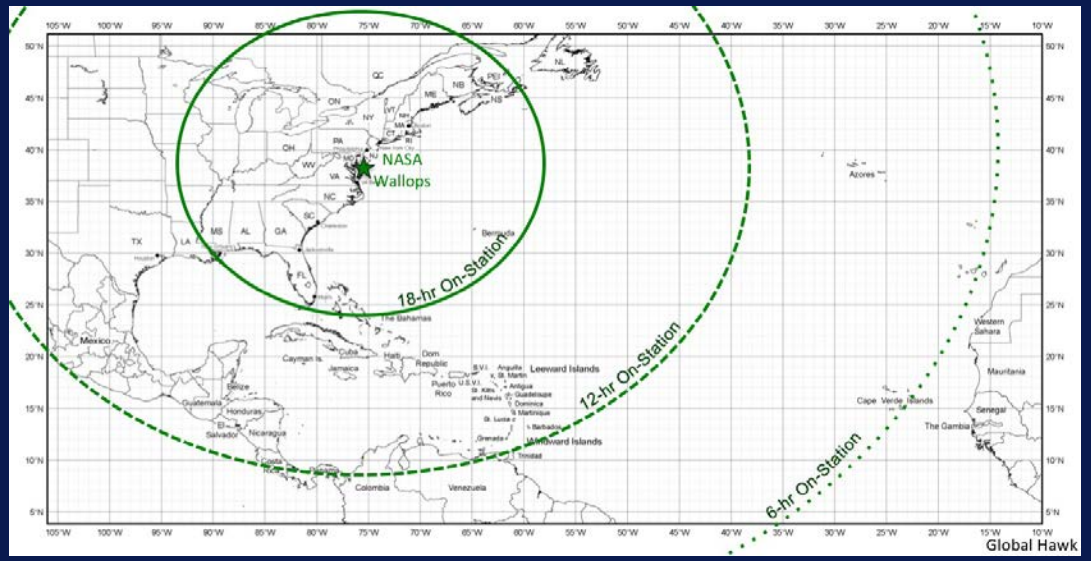
Objective 2: Cost-Operational Benefit Analysis

- **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)

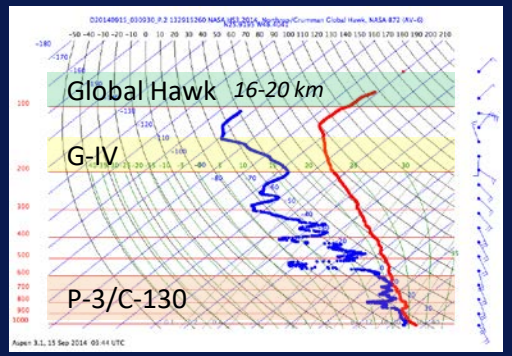
***PI**: Terry Hock, NCAR / Gary Wick, NOAA*

***Measurements**:*

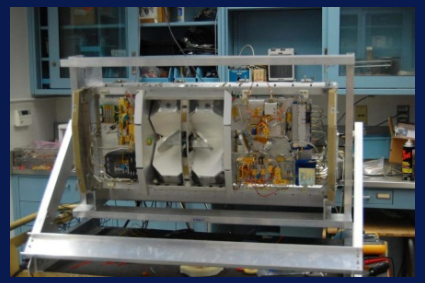
- *temperature, pressure, wind, humidity profiles*
- *90 dropsondes per flight*

***Resolution**:*

- *~2.5 m (winds), ~5 m (PTH)*



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



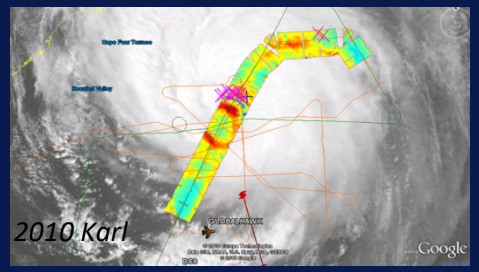
***PI**: Dr. Bjorn Lambrigtsen, JPL*

***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)

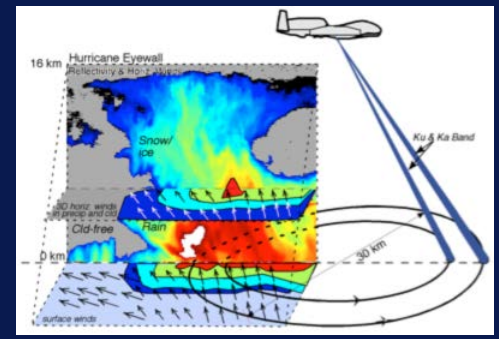
PI: Dr. Gerald Heymsfield, NASA GSFC

***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

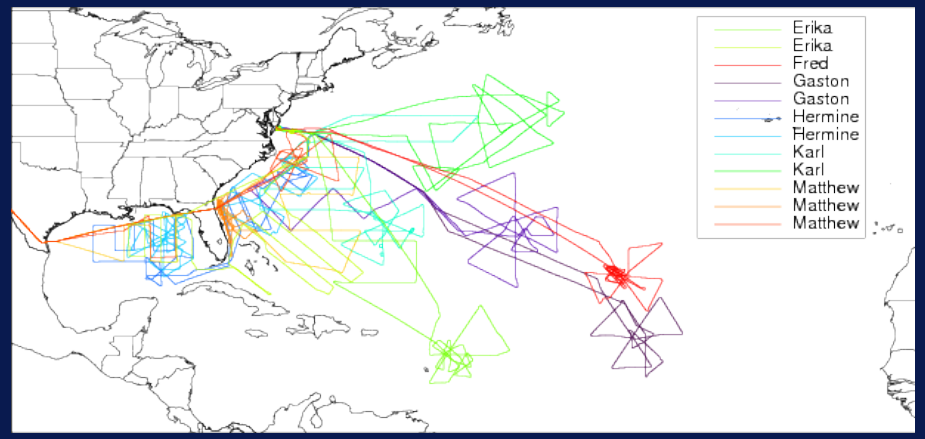
Hurricane Rapid Response (HRR) 2016

- 9 missions/4 named TCs
- Shift to operational deployment model
- Collaborations: NOAA IFEX, ONR TCI, & NAWDEX

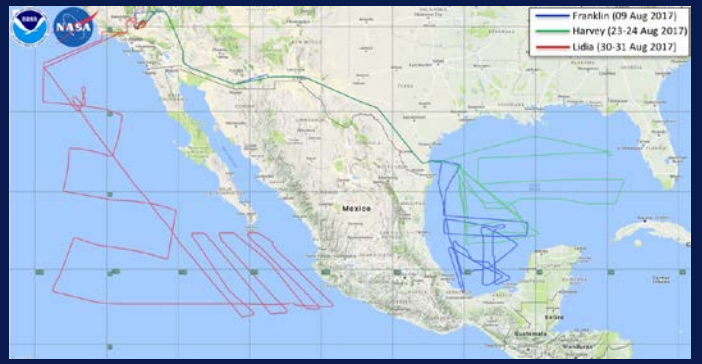
NASA EPOCH 2017

- 1st operational GPS dropsonde assimilation in GFS

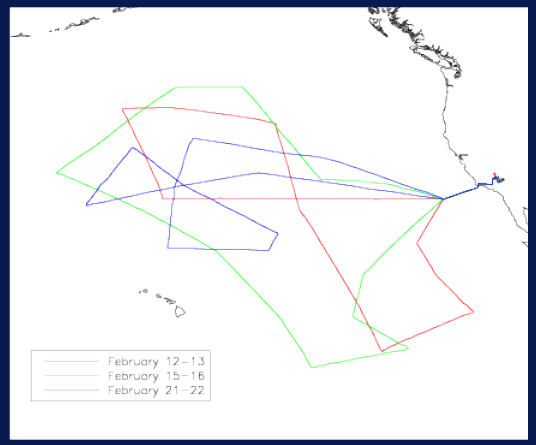
SHOUT Tropical Cyclone Campaigns 2015-2016



NASA EPOCH 2017



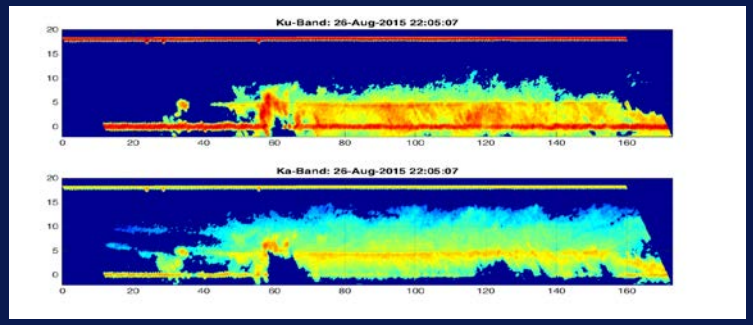
SHOUT ENRR 2016



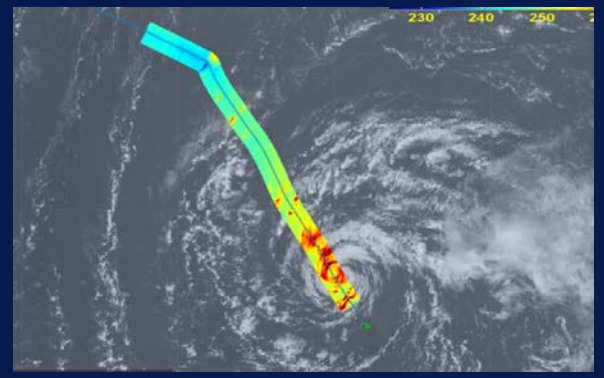
SHOUT Real-Time Data

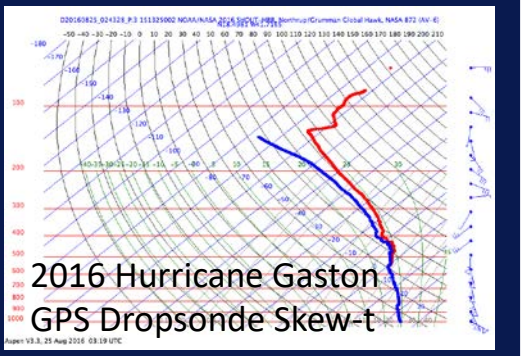
- Flexibility modifying Global Hawk flight tracks
  - *ATC coordination with ~30 min notice*
- High bandwidth real-time GH data access
  - *GPS dropsondes, HAMSR, & HIWRAP*
- Operational use of Global Hawk dropsonde data
  - *GPS dropsonde data routinely QCed and transmitted to the GTS*
  - *Used in real-time by forecasters at NOAA NHC*
  - *Real-time assimilation in operational models (e.g., GFS, HWRF, ECMWF)*

2015 TS Erika: HIWRAP Radar Cross-Section



2015 TS Fred HAMSR MW data





2016 Hurricane Gaston
GPS Dropsonde Skew-t

SHOUT Data Use at NHC

2016: Global Hawk dropsonde data cited in 10 NHC discussions (4 TCs)

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)

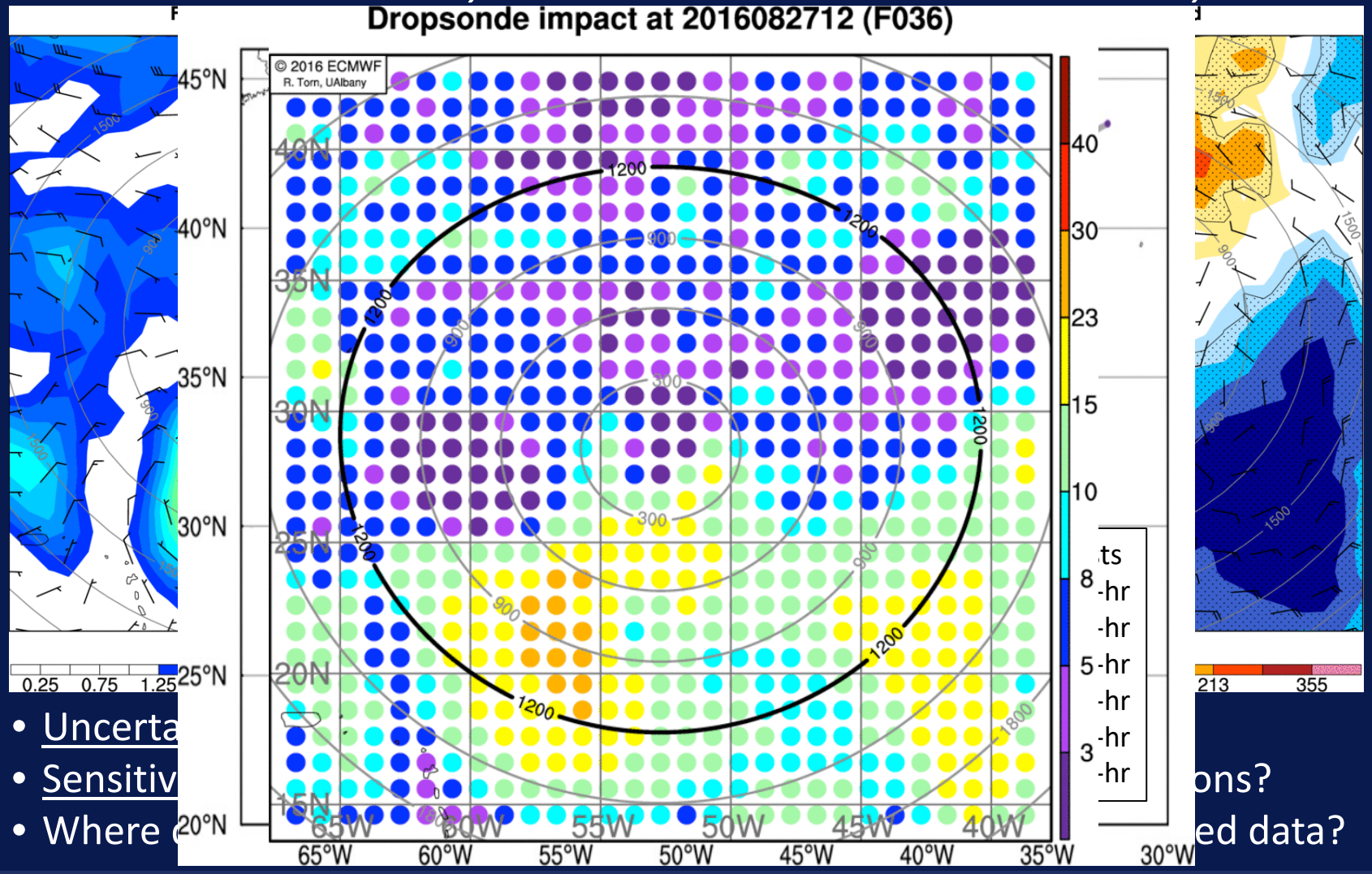
NOAA NHC Discussion #7

- *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 *ECMWF EPS ensemble* *Target Location* *Forecast Sensitivity*



- Uncerta
- Sensitiv
- Where

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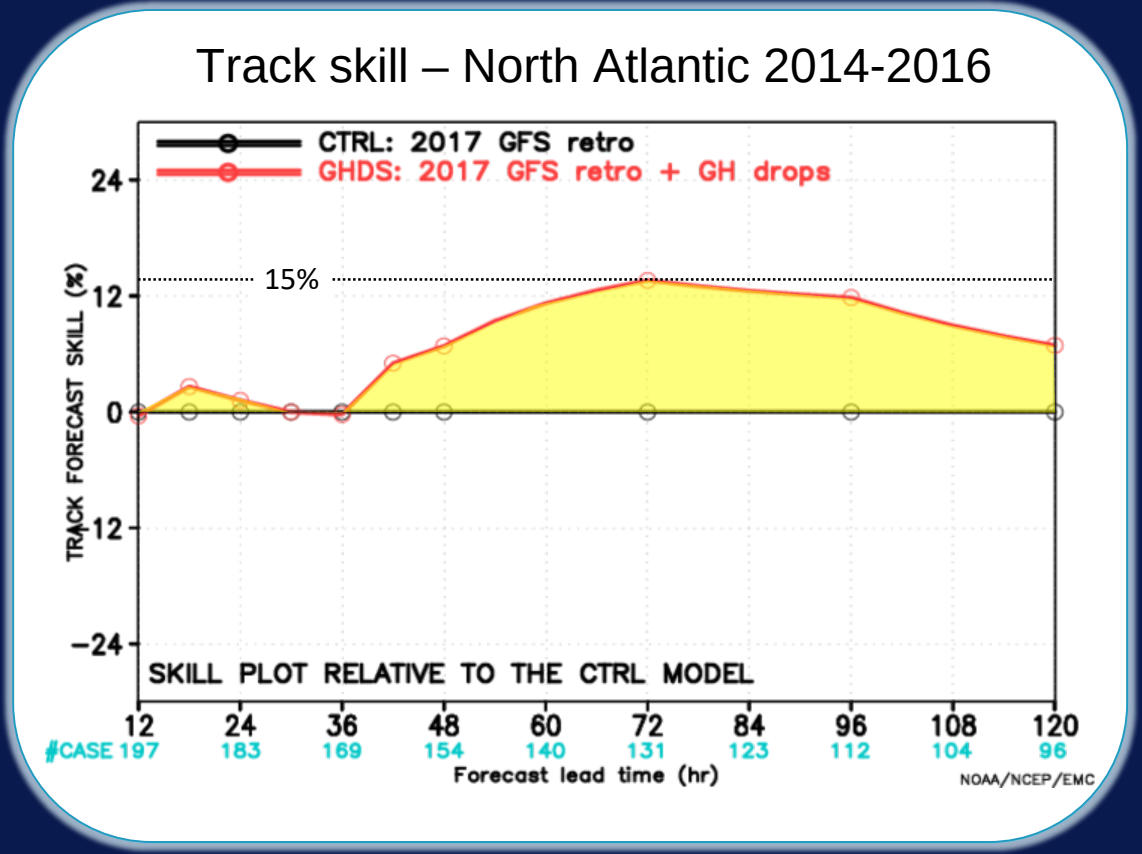
SHOUT Forecast Impact Studies

- **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

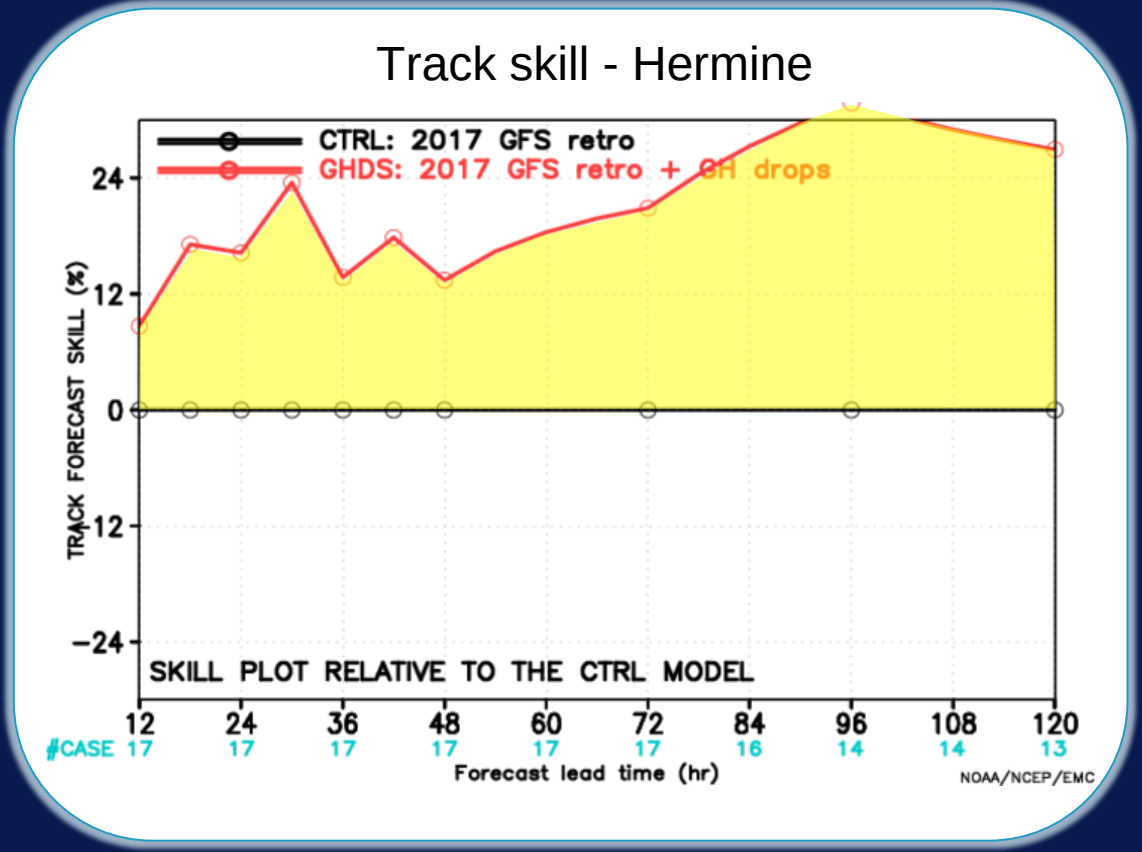
- Dropsonde impact on operational 2017 GFS Atlantic forecasts for Atlantic 2014-2016
- Peak improvement ~15% at 72 h
- Statistically significant improvements at 72 and 96 h



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

EMC Results – GFS Model
2016 Hurricane Hermine

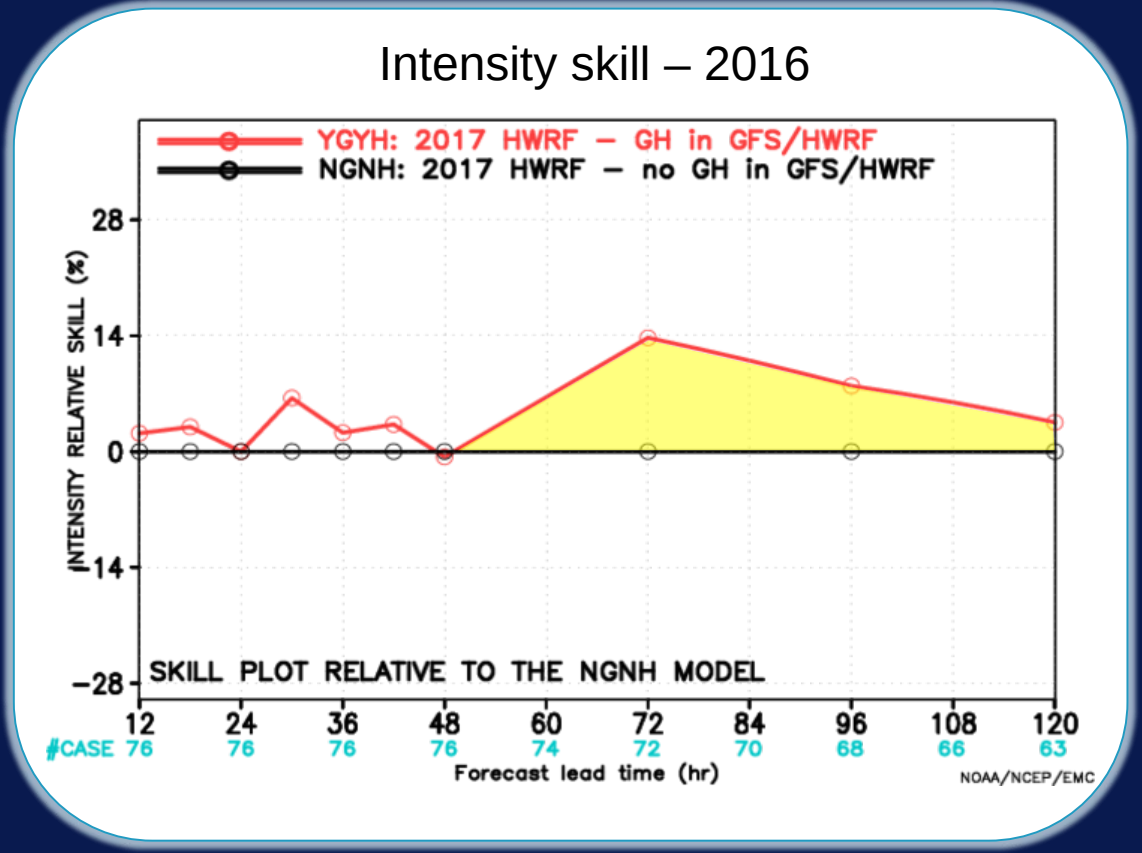
- Dropsonde impact on operational 2017 GFS forecasts of Hurricane Hermine
- Higher track uncertainty in spite of extensive reconnaissance from C-130 and P-3 (no G-IV).
- Large skill improvements with addition of Global Hawk GPS dropsondes



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)

Model		All Observations		Satellite Gap	
		Multi Storm	Matthew 16	Multi Storm	Matthew 16
HWRF	V2015	N/A	N/A	10%	30%
	V2017	15%	N/A	N/A	N/A
	HEDAS	10%	N/A	N/A	N/A
GFS	V2015	8%	N/A	8%	N/A
	V2017	12%	28%	N/A	N/A