Assessing UAS Observing Strategies for NOAA Earth Observations

Robbie Hood

Director, NOAA UAS Program

13 June 2017

NOAA UAS Strategic Vision and Goals (FY09 – FY15)

- *Vision*
  - UAS will revolutionize NOAA observing strategies by 2015 comparable to the introduction of satellite and radar assets decades earlier
- *Goals*
  - Goal 1: Increase UAS observing capacity
  - Goal 2: Develop high science-return UAS missions
    - *High impact weather observations*
    - *Marine observations*
    - *Polar observations*
  - Goal 3: Transition cost-effective, operationally feasible UAS solutions into routine operations

Long Endurance UAS

- Maximum Altitude *60,000 ft*
- Maximum Endurance *24 hrs*
- Maximum Payload Weight *1200 lbs*

High Altitude Long Endurance

- Maximum Altitude *40,000 ft*
- Maximum Endurance *24 hrs*
- Maximum Payload Weight *400 lbs (internal) – 2000 lbs (external)*

Medium Altitude Long Endurance

- Maximum Altitude *20,000 ft*
- Maximum Endurance *24 hrs*
- Maximum Payload Weight *13.5 lbs*

Low Altitude Long Endurance

- Maximum Altitude *24,000 ft*
- Maximum Endurance *15 hrs*
- Maximum Payload Weight *42 lbs*

Hybrid Fixed and Rotary Wing

Short Endurance UAS

- Maximum Altitude *1000 ft*
- Maximum Endurance *2 hrs*
- Maximum Payload Weight *2 lbs*

Low Altitude Short Endurance

- Maximum Altitude *3280 ft*
- Maximum Endurance *1.4 hrs*
- Maximum Payload Weight *1.7 lb*

Vertical Takeoff and Landing

- Maximum Altitude *20,000 ft*
- Maximum Endurance *2 hrs*
- Maximum Payload Weight *0.9 lbs*

Aircraft-Launched

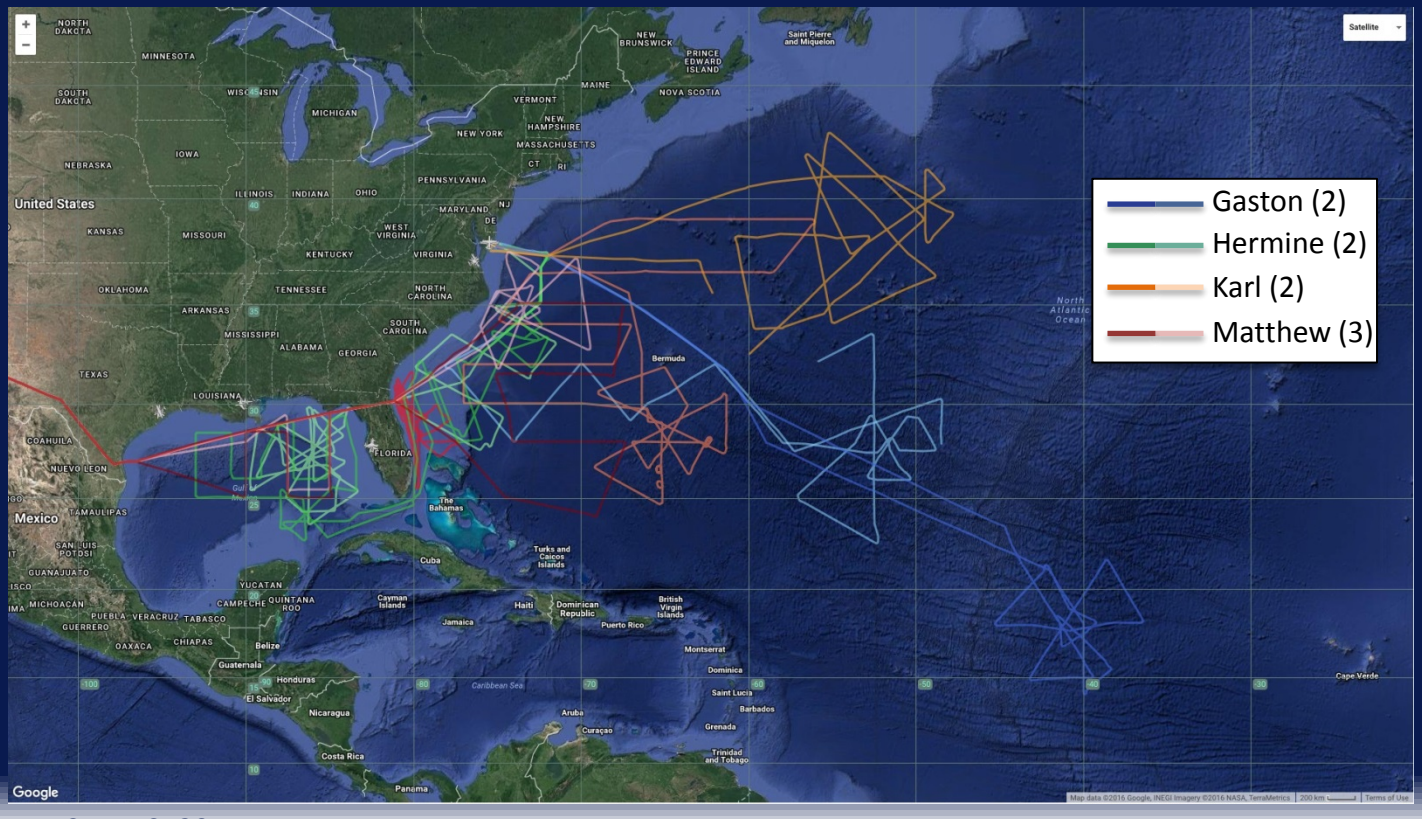
- Maximum Altitude *100,000 ft*
- Maximum Endurance *0.5 hrs*
- Maximum Payload Weight *3 lbs*

Balloon-Launched

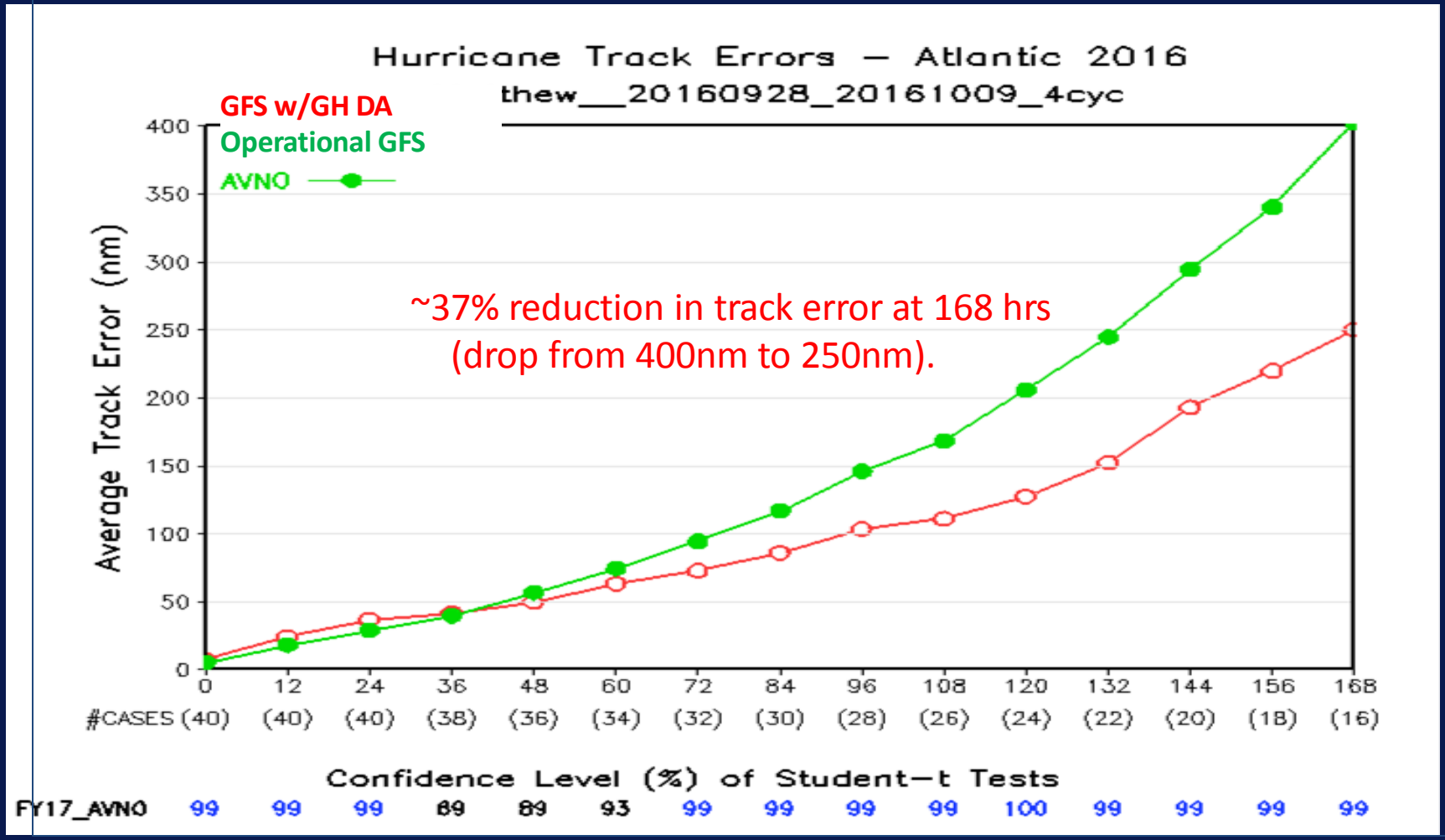
High Impact Science Focus Area

SHOUT 2016 Tropical Cyclones

- 9 flights with 3 consecutive flights over Hurricane Matthew
- 213 flight hours,
- 647 dropsondes deployed, a record 90 dropsondes in a single flight
- SHOUT team on call for 10 consecutive weeks



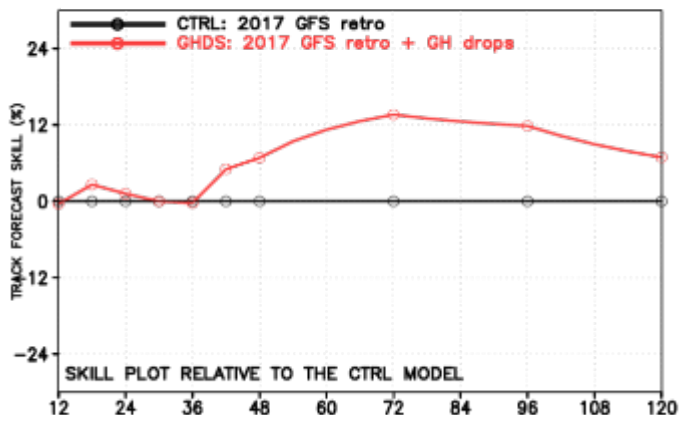
Potential of 2016 Hurricane Matthew Track Forecast Improvement



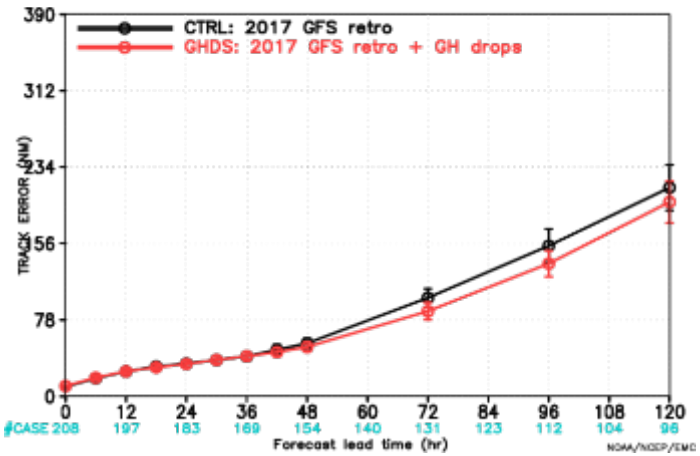
Results: GFS Atlantic 2014-16

- Results prove GH is VERY useful for improving hurricane track forecasts
- Peak improvement about 15% at 72 h
- Statistically significant improvement at 72 and 96 h

Track skill – 2014 all AL available

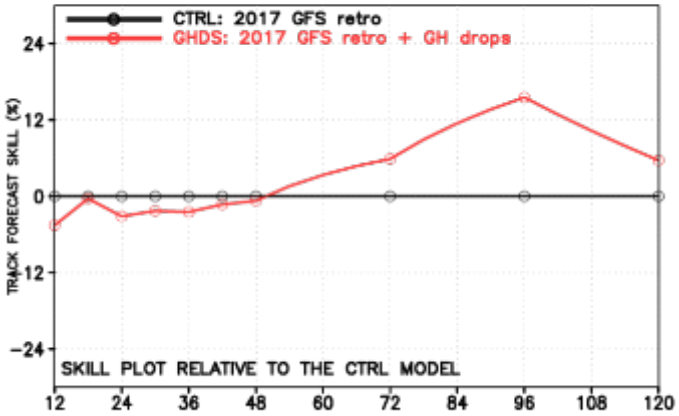


Track error – 2014 all AL available

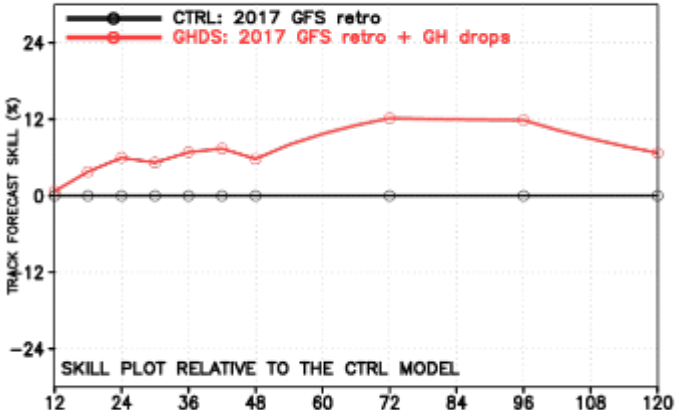


Results: GFS other basins 2016

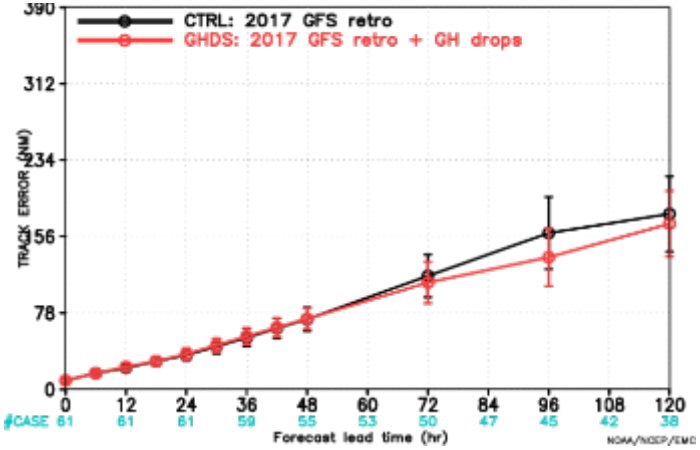
Track skill – EPAC



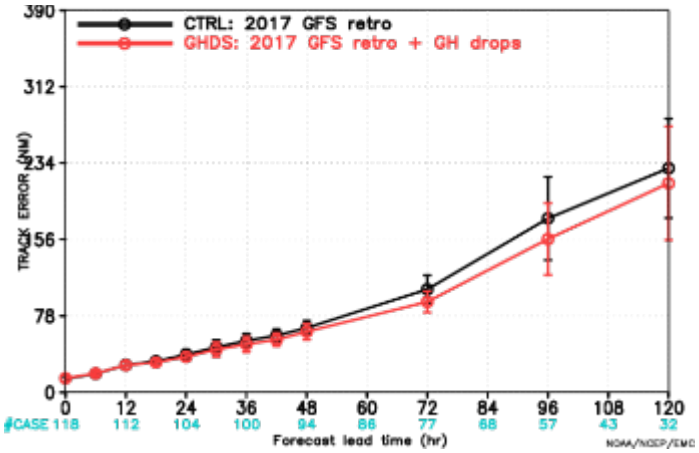
Track skill – WPAC



Track error – EPAC



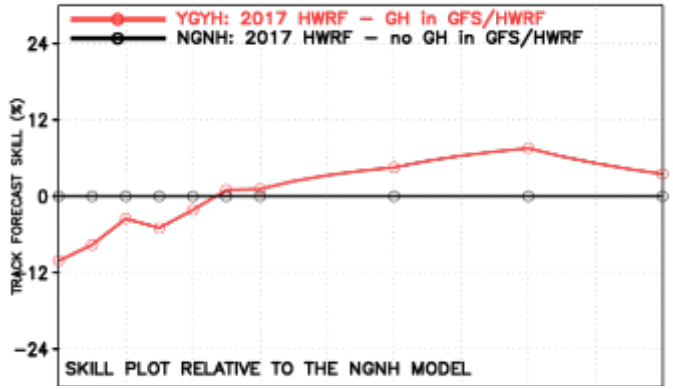
Track error – WPAC



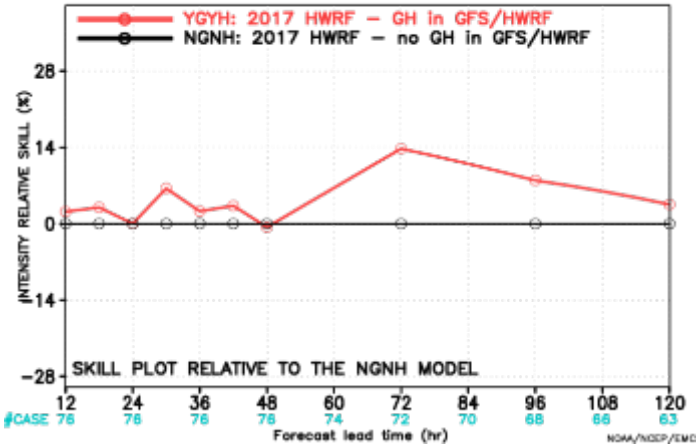
Results: HWRF Atlantic 2016

- Improvement in GFS has major impact on downstream models
- GFS retrospectives fed into new HWRF DA system
- Intensity improves by ~15% at 72 h

Track skill – 2016



Intensity skill – 2016



Standard Aircraft Program Cost
Daily and Per Flight Hour Global Hawk Operational Rates
OMB Circular No. A-126

	Cost Driver	Standard Rate	Qty	Qty	Cost Estimate: Per Day	Cost Estimate: Per Flight Hour
DIRECT COSTS - VARIABLE						
Crew Costs:						
Travel & Per diem (Domestic)	per traveler per day	$325.00	3	1	$975.00	
Maintenance (time/cycle based):						
Parts	per flight hour	$1,500.00	1	1		$1,500.00
Contracts	per flight hour	$1,800.00	1	1		$1,800.00
Engine Overhaul / Aircraft Refurbishment	incl in Maintenance	$400.00	1	1		$400
Fuel - Jet A (eff: 1 Feb 2013)	per gal per flight hr	$4.25	1	75		$318.75
Other:						
Sondes (included in science costs)	each sonde	$690.70	0	1	$0.00	
Communications	per flight hour	$348.00	1	1		$348.00
DIRECT COSTS - FIXED						
All Labor - Salaries, Benefits, Training	per project day	$11,492.00	1	1	$11,492.00	
INDIRECT COSTS						
Admin/Operations overhead:	per project day	$1,827.04	1	1	$1,827.04	
Depreciation	per project day	$767	1	1	$767.00	
Self-insurance costs:	per flight hour	3.83	1	1	$3.83	$0.00
TOTAL COSTS (per day & flight hour):					**$15,064.87**	**$4,366.75**

Standard Aircraft Program Cost
Daily and Flight Hour Global Hawk Operational Rates Deployed
OMB Circular No. A-126

	Cost Driver	Standard Rate	Qty	Qty	Cost Estimate: Per Day	Cost Estimate: Per Flight Hour
DIRECT COSTS - VARIABLE						
Crew:						
Travel & Per diem (Domestic)	per traveler per day	$325.00	21	1	$6,825.00	
Maintenance (time/cycle based):						
Parts	per flight hour	$1,500.00	1	1		$1,500.00
Contracts	per flight hour	$1,800.00	1	1		$1,800.00
Engine Overhaul / Aircraft Refurbishment	incl in Maintenance	$400.00	1	1		$400
Fuel - Jet A (eff: 1 Feb 2013)	per gal per flight hr	$4.25	1	75		$318.75
Airfield Fees (WFF services, etc.)	per project day	$1,400.00	1	1	$1,400.00	
Other:						
Sondes (included in science costs)	each sonde	$690.70	0	1	$0.00	
Shipping / Transportation	per flight hour	$200.00	1	1		$200.00
Communications	per flight hour	$348.00	1	1		$348.00
DIRECT COSTS - FIXED						
All Labor - Salaries, Benefits, Training	per project day	$11,492.00	1	1	$11,492.00	
INDIRECT COSTS						
Admin/Operations overhead:	per project day	$3,224.00	1	1	$3,224.00	
Depreciation	per project day	$767	1	1	$767.00	
Self-insurance costs:	per flight hour	$3.83	1	1	$3.83	$0.00
TOTAL COSTS (per day & flight hour):					**$23,711.83**	**$4,566.75**

Three Kinds of UAS Observations used in Environmental Profiling and Initiation of Convection (EPIC) Experiment

Meteomatics Meteodrone

CU Fixed-wing TTwistor

OU CopterSonde

The three sUAS deployed for the EPIC intercomparison field experiment in October 2016.

Meteodrone is about 80% the size, but only 12% of the weight, of the CopterSonde.

TTwistor has a 10-ft wingspan – a dual-engine version of the Tempest used in VORTEX-2.

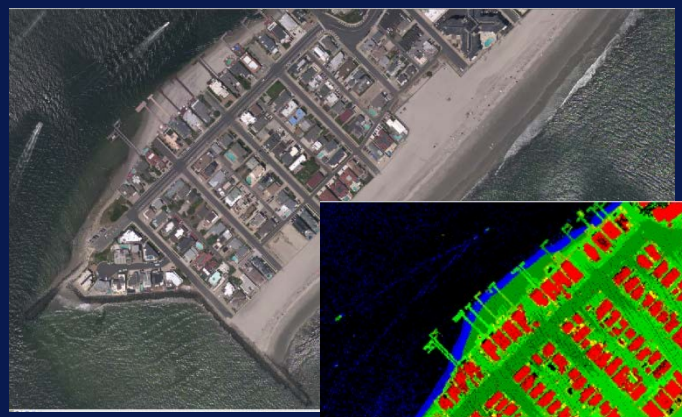
Marine Science Focus Area

UAS for NOAA's National Geodetic Survey

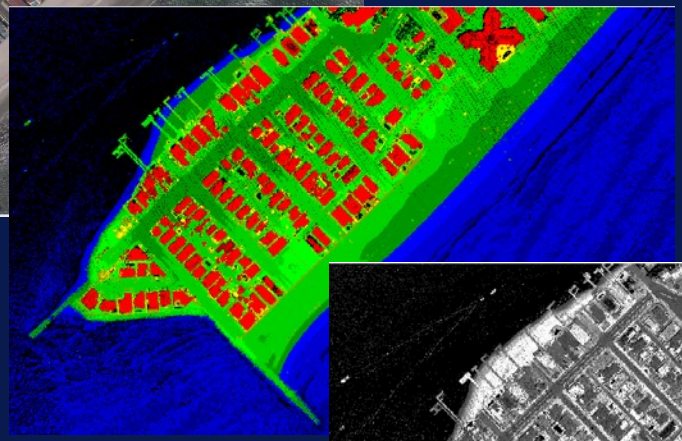
- National Geodetic Survey within the National Ocean Service leads Federal effort to measure gravity around the nation to dramatically improve the resolution of floodplain maps used by communities to better prepare for severe storms, floods and other natural disasters.
- NOAA Small Business Innovative Research (SBIR) Phase I and II projects
- Aurora Centaur optionally piloted UAS
- Micro-g LaCoste Gravimeter
- SBIR Phase III award to begin operational data collection

Other National Geodetic Survey Products

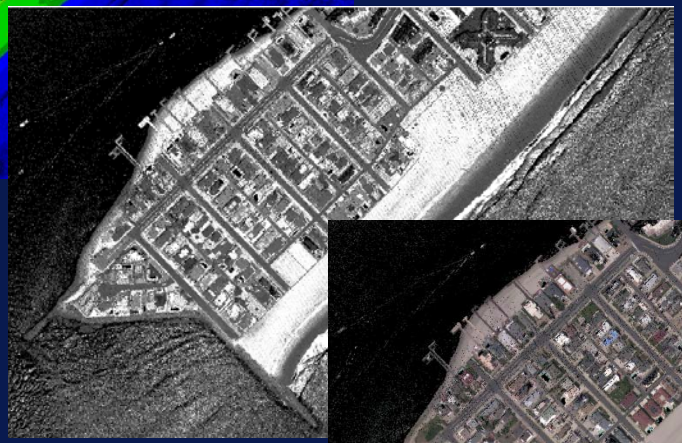
Shoreline



Ortho Mosaic Imagery

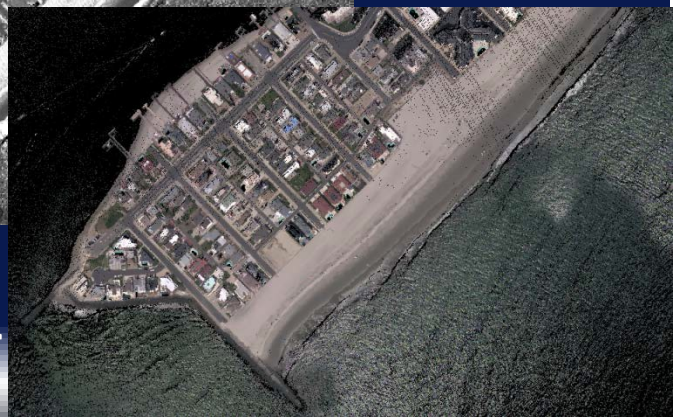


Lidar Point Cloud and DEMs (elevation)



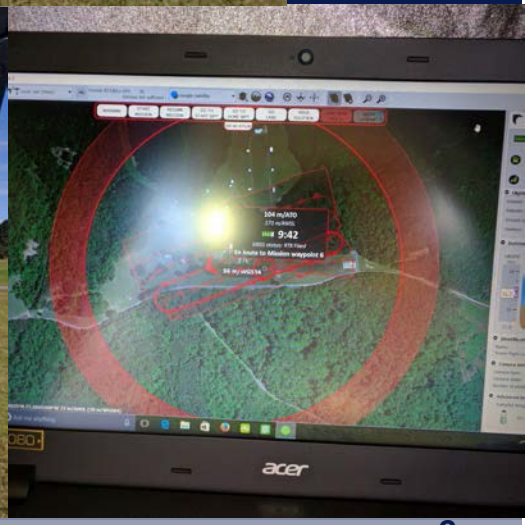
Lidar Point Cloud (intensity)

Map once use many times!

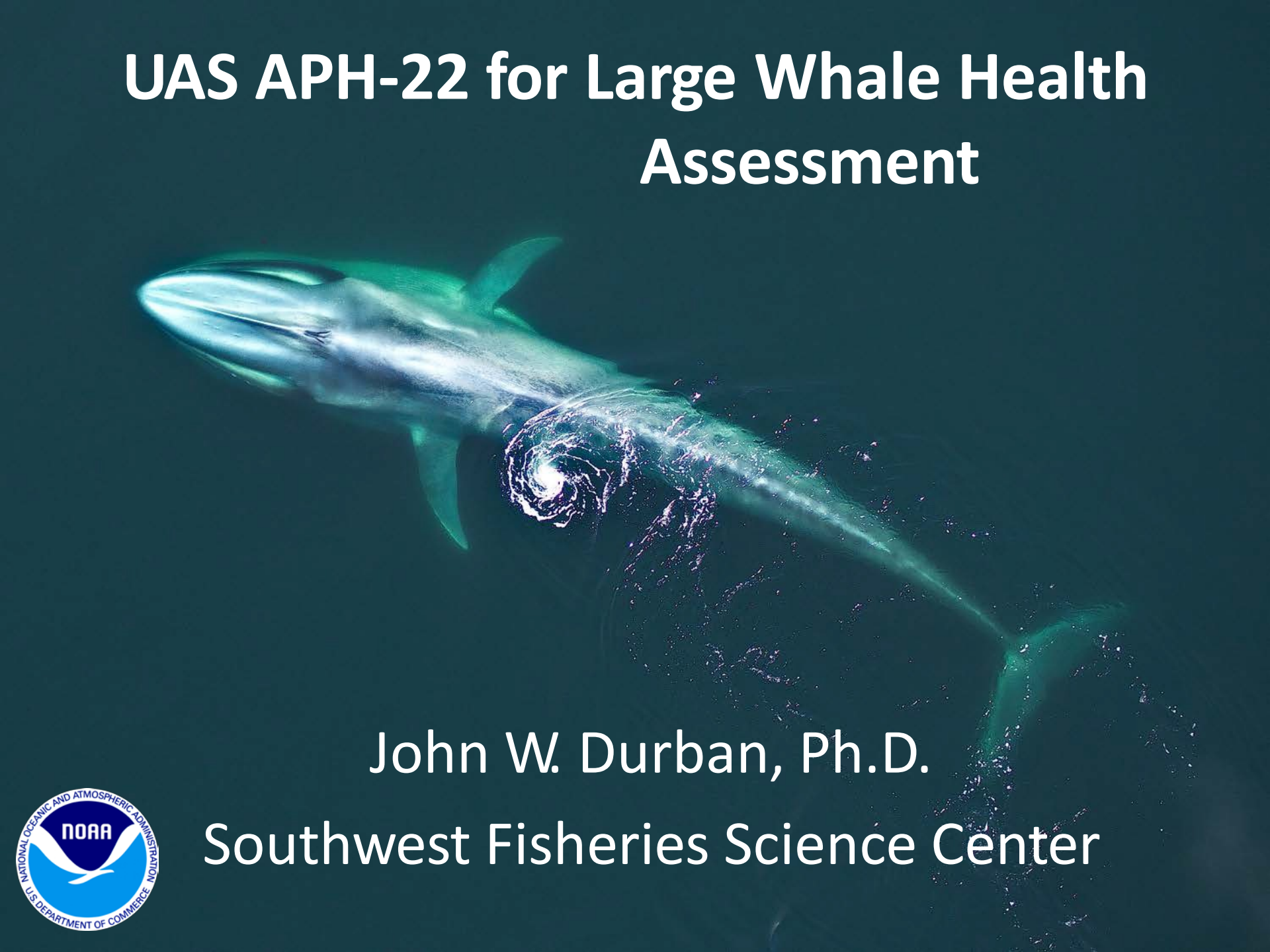


RGB Colorized Lidar Point Cloud

eBee RTK Survey-grade mapping drone
Capture aerial photography to produce orthomosaics & 3D models with absolute accuracy of down to 3 cm - without GCP
https://www.sensefly.com/drones/ebee-rtk.html



UAS APH-22 for Large Whale Health Assessment



John W. Durban, Ph.D.

Southwest Fisheries Science Center

APH-22 (aerialimagingsolutions.com)

- Vertical take-off and landing (VTOL) UAS
- 4.5 lbs, 32” wingspan
- Powered by 4-cell Lithium Polymer battery
- Sensors:
  - E-PM2 Olympus camera in gimbal
  - Laser Altimeter (SF11/C)
  - Infra-red camera (FLIR Tau 324)

Approach

- Photogrammetry

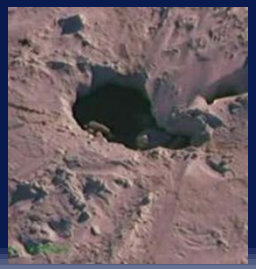
- Blow sampling

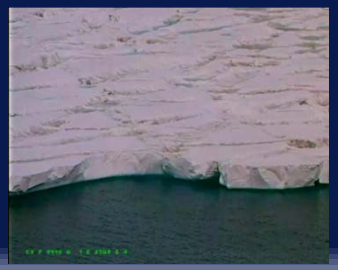
Polar Science Focus Area

Operation **Deep Freeze 2016**

USCG - NOAA - NSF - Aerovironment Collaboration

- **Two-month Polar Star Cruise to Antarctica**
- **20 UAS flights flown by Aerovironment**
  - **Beyond Line of Sight operations out to 46 kilometers**
  - **High resolution imaging payload testing**
- **Real-time satellite imagery provided by National Ice Center and IMARSAT**





Manned vs unmanned aerial surveys of cetaceans in the Arctic: Operations and preliminary results

Robyn Angliss and Megan Ferguson*

NOAA Fisheries

Alaska Fisheries Science Center

Marine Mammal Laboratory

Amy Kennedy

Joint Institute for the Study of the Atmosphere and Ocean

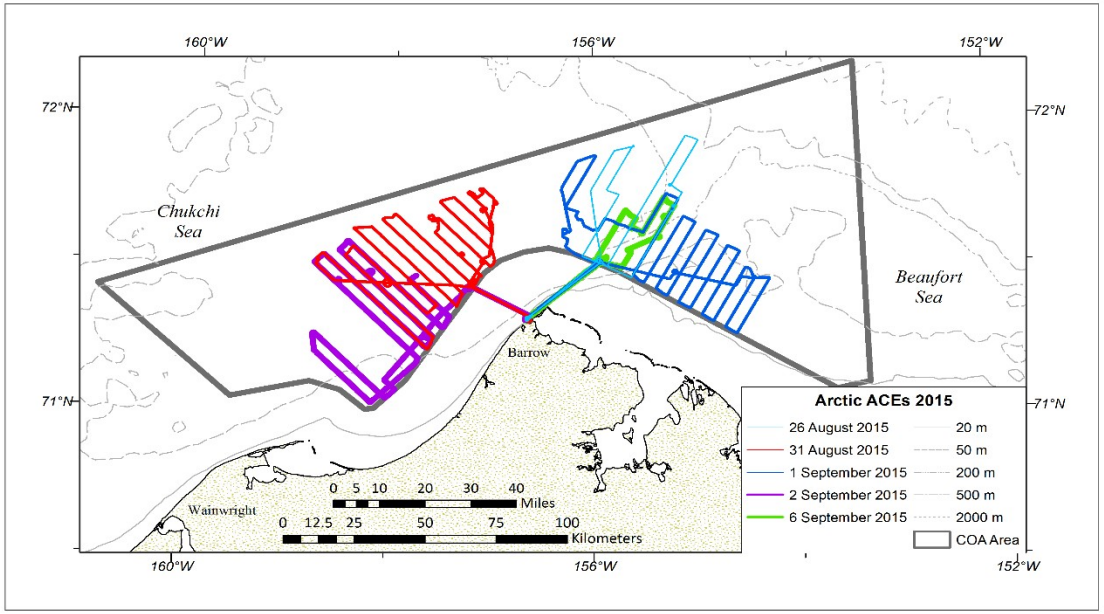
Key participants: Naval Surface Warfare Center Dahlgren Division, Phil Hall, Van Helker, Bob Lynch, Amy Willoughby, Van Helker, Amelia Brower, Janet Clarke, Todd Sformo, Christy Sims, Brenda Rone, Cynthia Christman, Corey Accardo, Jen Gatzke, Vicki Beaver, Suzie Hanlan, Lisa Barry, Marjorie Foster, Laura Ganley, Leah Crowe, Karen Vale, Heather Foley, and Jess Taylor.

* Analytical lead

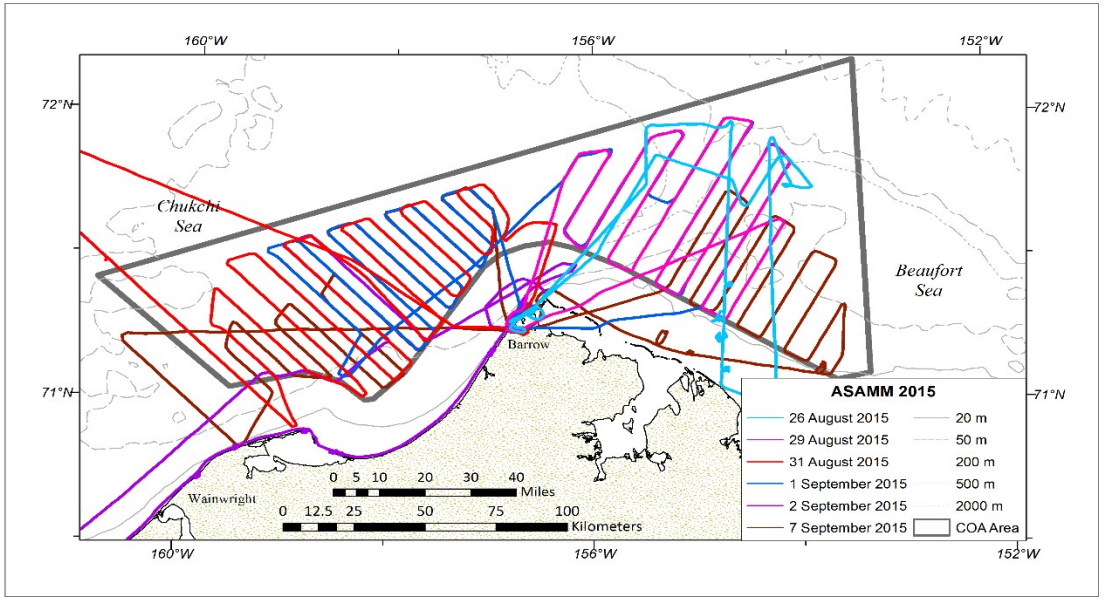
Unmanned Aerial System: Insitu ScanEagle®

Other equipment: PEMDAS sensor, portable weather station, WebAdapt and Nowcasting, access to FAA system

UAV flights



Manned flights



Three New SBIR Projects For Shipboard Operations

- Two for greenhouse gas and soot observations
- One for boundary layer meteorological observations

Contact Information

UAS Web Site: uas.noaa.gov

Questions should be directed to:

Robbie Hood - NOAA UAS Program Director (robbie.hood@noaa.gov / 303-905-3411)

Backup Slides

UAS Program Definitions

- **Unmanned Observing Platform** – ***unmanned aircraft or marine system with launch, recovery, communication, and ground control packages***

- **Payload Sensor** – ***instrument capable of collecting observation from an observing platform***

- **Observing System** - ***Payload, platform, data storage components working as a system to acquire an observation***

- **Observing Strategy** – ***application of a process or plan to use an observing system to acquire an observation***

Critical Elements Needed to Mature a Complete Observing Strategy