Hurricane and Severe Storm Sentinel (HS3): A Multi-Year NASA Earth Venture-1 Investigation

Scott A. Braun, NASA/GSFC, Paul A. Newman, NASA/GSFC, Marilyn Vasques, NASA/ARC

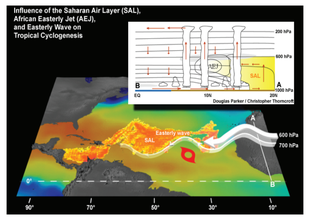
Introduction

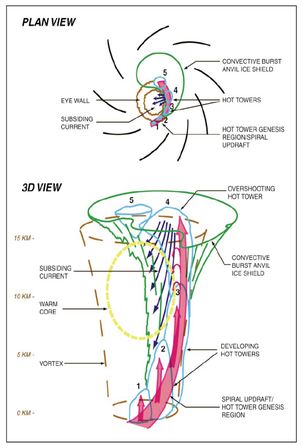
HS3 will obtain observations critical to improved understanding of genesis and intensification processes and to assessing the impact, both in terms of research and applications, of advanced observing technologies on modeling and analysis. HS3 will obtain unprecedented observations of the storm environment and inner-core region by deploying two of NASA's new set of Global Hawk (GH) aircraft, capable of 25-30-h long flights from NASA's Wallops Flight Facility (WFF) in Virginia.

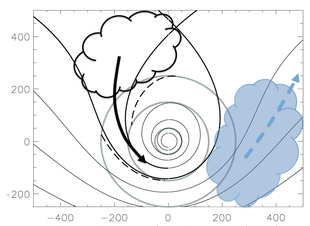
Science Goals

Overarching Science Goals
- What is the role of the large-scale environment in Atlantic tropical cyclone genesis and intensification?
- What is the role of storm internal processes such as convective bursts and vortical hot towers?
- To what extent ar these processes predictable?

Specific goals include addressing:
- The structure and role of the Saharan Air Layer (SAL)
- Genesis processes such as the role of wave "pouches" and top-down or bottom-up development
- Convective bursts and associated wind field changes
- Warm-core formation and evolution





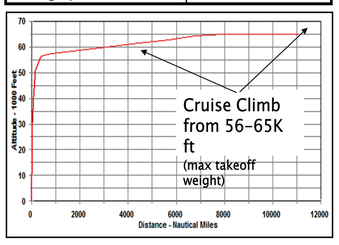


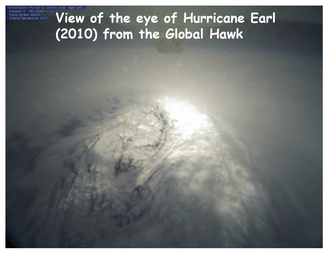
From Reimer and Montgomery (2011)

From Heymsfield et al. (2001)

HS3 Observing Strategy
- HS3 will utilize two Global Hawk unmanned airborne systems, one specifically designed for sampling the storm environment and the other for storm internal processes.
- HS3 will operate from the Wallops Flight Facility in Virgina
- HS3 includes 3 one-month deployments in 2012-2014, with 270 science flight hours (approximately 10-11 flights) per deployment.

Endurance	> 30 hours
Range	>11,000 nmi
Service Ceiling	65,000 ft
Airspeed (55K+ ft)	335 KTAS
Payload	1,000-1,500 lb
Length	44 ft
Wingspan	116 ft

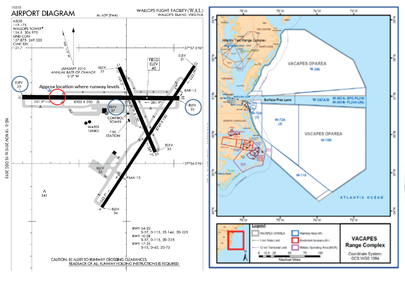


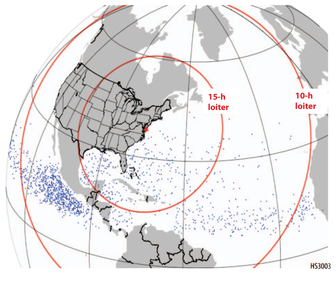


Improved On-Station Time for HS3 compared to GRIP

Flights will be based at the Wallops Flight Facility in Virginia, providing multiple runways, access to restricted air space, and more rapid access to the Atlantic for much longer on-station time.

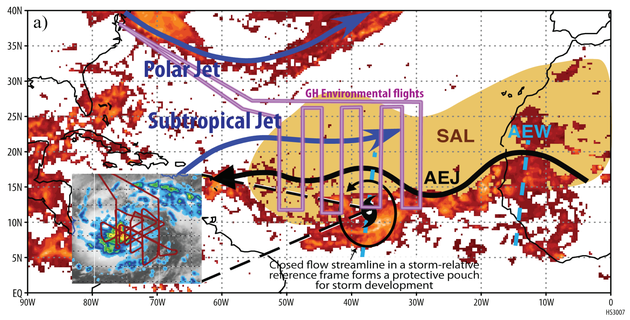
The plot below-right shows the approximate ranges for on-station times of 20 and 10 hours, assuming a 30-h flight. Also shown are the formation locations of tropical cyclones between 1940-2007.



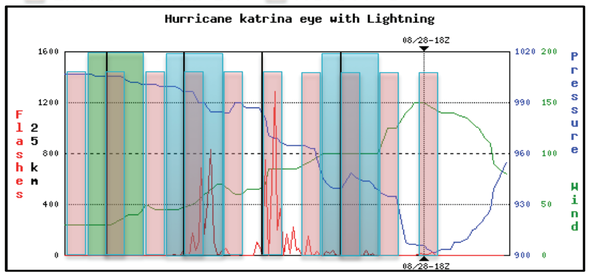


Science Operations Concept

- The Environmental GH will be tasked with sampling the 3D environment surrounding tropical systems, including the detailed structure of the SAL (dust vertical structure, temperature and humidity, winds).
- The Over-Storm GH will do repeated sampling of inner-core precipitation and wind structure.
- The aircraft will fly in-series instead of simultaneously because of manpower costs. However, one GH can be going out while the other is returning.
- Turn-around time for a given GH will be ~48 h.
- Flights will be coordinated with other research and operational aircraft to improve spatial and temporal sampling..



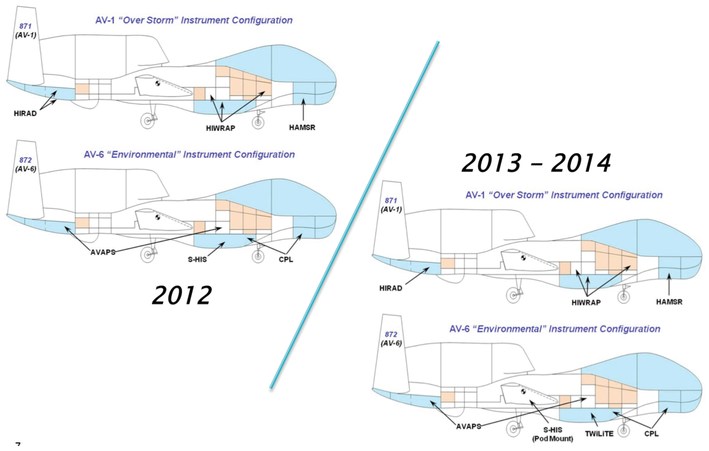
Over–Storm GH
Environmental GH
NOAA P–3



HS3 Payloads

Measurements from the Environmental GH Payload
- Continuous sampling of temperature and relative humidity in the clear-air environment from the scanning High-resolution Interferometer Sounder (S-HIS).
- Continuous wind profiles in clear air from the TWiLiTE wind lidar.
- Full tropospheric wind, temperature, and humidity profiles from the AVAPS dropsonde system.
- Aerosol and cloud layer vertical structure from CPL.

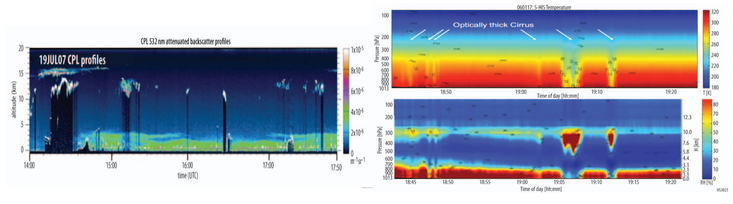
Measurements from the Over-Storm GH Payload
- Three-dimensional wind and precipitation fields from the HIWRAP conically scanning Doppler radar.
- Surface winds and rainfall from the Hurricane Imaging Radiometer (HIRAD).
- Measurements of temperature, water vapor, and liquid water profiles, total precipitable water, sea-surface temperature, rain rates, and vertical precipitation profiles from HAMSR.



Instruments

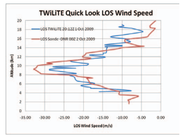
Cloud Physics Lidar (CPL): Multi-wavelength backscatter lidar (CALIPSO simulator) that provides information on the radiative and optical properties of cirrus and subvisual cirrus clouds and aerosols (below left).

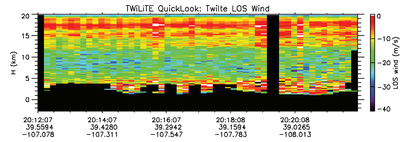
Scanning High-resolution Interferometer Sounder (S-HIS): The S-HIS interferometer sounder provides temperature and water vapor profiling (below right) in clear-sky conditions.



Instruments (continued)

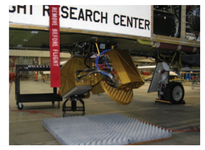
Tropospheric Wind Lidar Technology Experiment (TWiLiTE): TWiLiTE is a scanning direct-detection Doppler lidar that will collect full profiles of the vertical structure of the horizontal wind field in clear-air conditions from the lower stratosphere to the surface.



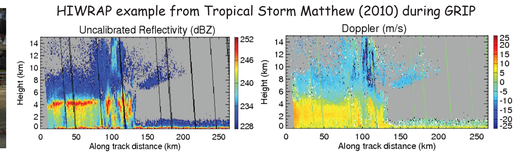


Dropsondes: The Advanced Vertical Atmospheric Profiling System (AVAPS) dropsonde system provides in situ, high vertical resolution profiles of basic atmosphere state variables including temperature, pressure, humidity and winds. AVAPS can release up to 89 sondes per flight.

High-altitude Imaging Wind & Rain Airborne Profiler (HIWRAP): HIWRAP is a dual-frequency (Ku- and Ka-band, or ~14 and 35 GHz), dual-beam (30° and 40° incidence angle), conically scanning Doppler radar. HIWRAP will map radar reflectivity and full tropospheric winds from cloud and precipitation volume backscatter measurements, and estimate ocean surface winds using scatterometry techniques similar to NASA's QuikScat.

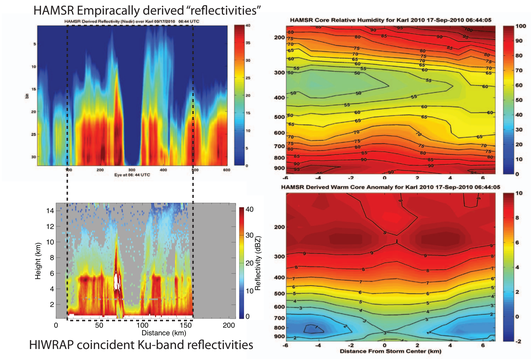


HIWRAP example from Tropical Storm Matthew (2010) during GRIP



High Altitude MMIC Sounding Radiometer (HAMSR): HAMSR is an all-weather atmospheric sounder. HAMSR will monitor the atmospheric state by retrieving 3-dimensional profiles of temperature, water vapor and cloud liquid water. The measurements can also be used to estimate precipitation rates and provide information on hydrometeor distributions. HAMSR scans cross track below the GH and has a ±45° field of view.

HAMSR Empiracally derived "reflectivities"

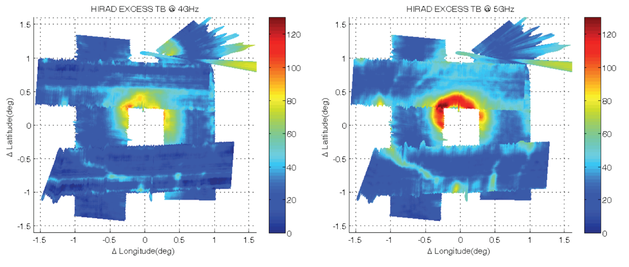


(Right) HAMSR retrieved eye humidity and temperature during Hurricane Karl's intensification during GRIP

(Left) Top panel is HAMSR empiracally derived reflectivities during a crossing of Hurricane Karl. Bottom panel is the coincident Ku-band radar reflectivity from HIWRAP.

HIWRAP coincident Ku-band reflectivities

Hurricane Imaging Radiometer (HIRAD): HIRAD is a C-band radiometer that has been developed to retrieve ocean surface wind speed and rain rate within tropical cyclones through category 5 hurricane intensity. Similar in concept to NOAA's SFMR, HIRAD adds the capability for cross-track wind retrievals. The example below is from the GH's first ever hurricane flight over Hurricane Earl during GRIP.



Schedule

- Aug-Sept.2011
  Completed Test flights for CPL, HAMSR, S-HIS, AVAPS at Dryden Flight Research Center
- Sept. 1-Oct. 5, 2012
  First deployment at Wallops
- Aug. 23-Sept. 23, 2013-14
  Second and third deployments at Wallops

Modeling Activities

- HS3 will utilize the NASA GEOS-5 model and the Advance Research version of the WRF model for model evaluation and improvement, data assimilation, and physical process studies.
- HS3 will collaborate with NOAA on evaluating/improving the NCEP HWRF model and the Navy COAMPS model through the Hurricane Forecast Improvement Project (HFIP)

Data Products

- All HS3 data products will be available for free from the HS3 archive
- Products available within 6-9 months of the deployments
- Real-time products to be made available on a best-effort basis

Project information
Please visit the HS3 web page at http://www.espo.nasa.gov/hs3

	Measurements	Horizontal Resolution	Vertical Resolution	Measurement error	Available in RT (yes/no)	Comments
CPL!	Attenuated backscatter profiles	1-sec to 1-min depending on KU system	30 m	35%	YES	Horizontal resolution depends on performance of Ku system
SHIS!	IR TB spectra	2 km	NA	< 1 K	TBD	
	Preliminary Temperature profiles	2 km	1-3 km	1-2 K	YES	Profiles will be updated after the compaign using better ancillary data
	Preliminary Humidity profiles	2 km	1-3 km	<20%	YES	Profiles will be updated after the compaign using better ancillary data
TWiLITE	Doppler velocity	2 km	250 m	<2 m/s	YES	Profiles will be updated with improved measurement error (<2 m/s) in post processing using better ancillary data
	Horizontal winds	4-8 km	250 m	<2 m/s	TBD	
AVAPS	Profiles of temperature	Varies	5-15 m	0.1°C (0.2°C)	YES	
	Profiles of humidity	Varies	5-15 m	1% (5%)	YES	
	Profiles of wind	Varies	5-15 m	0.1 m/s (0.5 m/s)	YES	
	Profiles of pressure	Varies	5-15 m	0.1 hPa (1.0 hPa)	YES	
HIWRAP	Reflectivity	1.0 km	0.2 km	1 dBZ	TBD	
	Doppler velocity	1.0 km	0.2 km	1.0 m/s	TBD	Data likely from a limited number of fixed azimuths
	Horizontal winds	1.0 km	0.5 km	2 m/s	TBD	
	Surface winds	2.0 km	N/A	2 m/s	TBD	
HAMSR	Brightness Temperature	2 km	NA	0.1-0.6K	YES	All channels, full swath; images & data
	Profiles of temperature	2 km	2 km	2 K	YES	Non-precipitating scenes only; images & data; preliminary profiles
	Profiles of humidity	2 km	2 km	<20%	YES	Non-precipitating scenes only; images & data; preliminary profiles
	dBZ product	2 km	2 km	3-8 dBZ	YES	Precipitating scenes only; images & data; preliminary profiles
	TPW	2 km	NA	TBD	YES	Non-precipitating scenes only; images & data
	CAPE, LI, etc.	2 km	NA	TBD	TBD	Depending on availability of computing resources
HIRAD	Brightness Temperature	<3 km	NA	0.2-0.3K	TBD	New instrument that has not flown on GH, so not sure yet what it can deliver.
	Surface wind speed	<3 km	NA	1-5 m/s	TBD	Possibly no RT data in 2012, but then winds and rain in 2013.
	Surface rainfall rate	<3 km	NA	TBD	TBD	
	Surface temperature	<3 km	NA	TBD	TBD	