Tropical Cyclone Forecasting and Airborne Observations: NHC's Perspective

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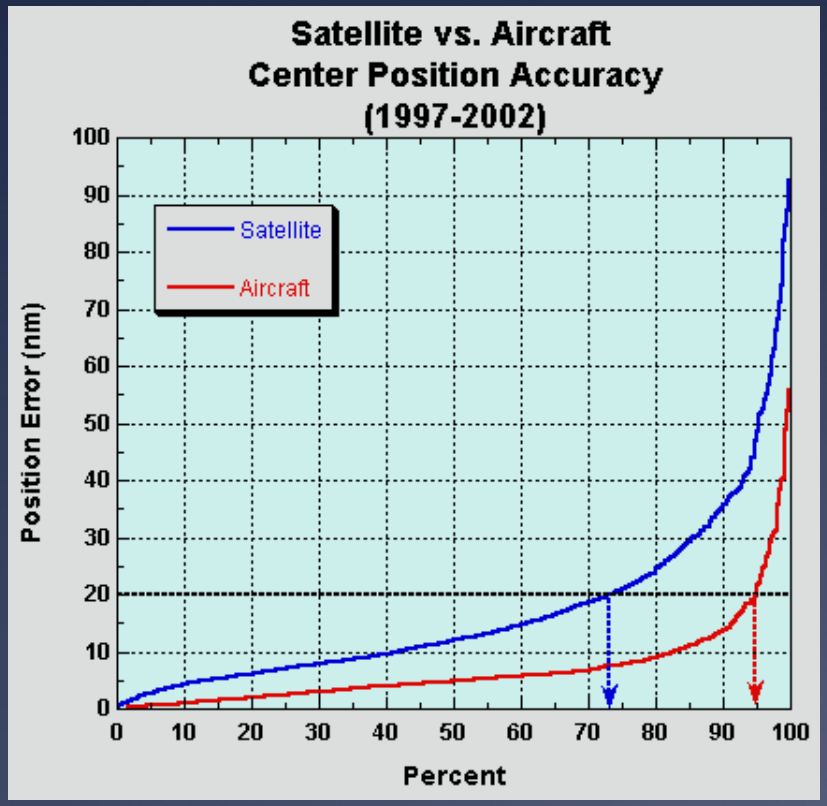
NOAA's Tropical Cyclone Responsibilities

- Tropical cyclone analyses, forecasts, and warnings from the African coast to the Date Line.
- Forecast track and intensity out to 5 days for marine avoidance and public awareness.
  - Maximum winds for public preparedness and recovery preparation
  - Hurricane and tropical storm wind radii for evacuation timing and marine avoidance.
  - Storm surge for evacuation.
  - Rainfall for potential inland flooding.
  - Central pressure supports model initialization and surge prediction.

Aircraft Requirements (NHOP)

- Location of FL and surface center.
- Continuous surface and FL winds, surface rain rate, FL T, Td, SST.
- SLP at center.
- Radar reflectivity and Doppler radials.

Why Do We Want Reconnaissance Data?



- Initial Position Accuracy
  - About ¼ of satellite position estimates are off by more than 20 n mi.

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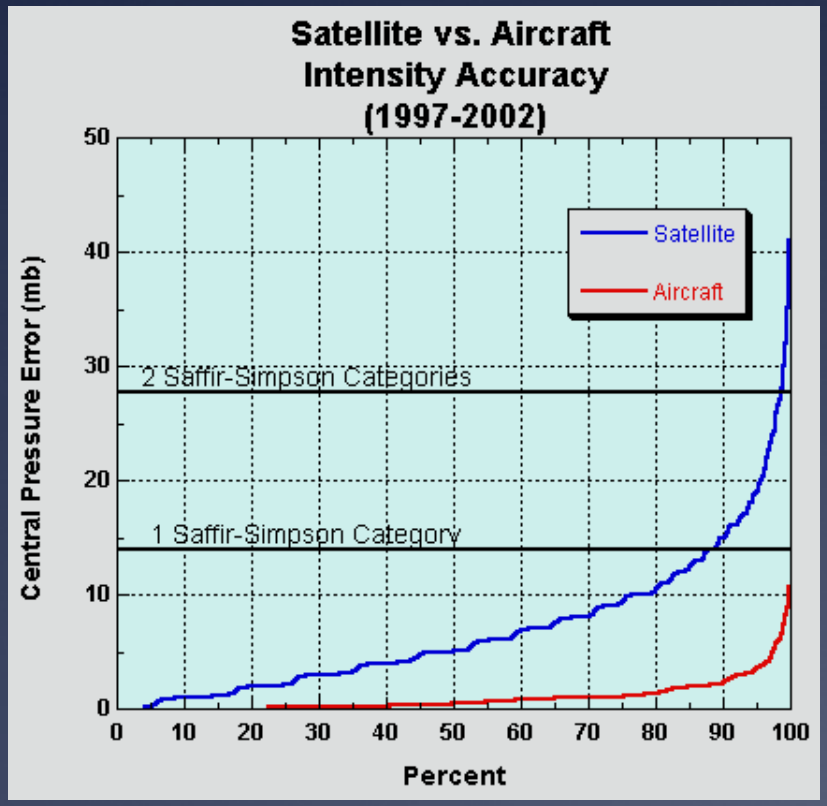
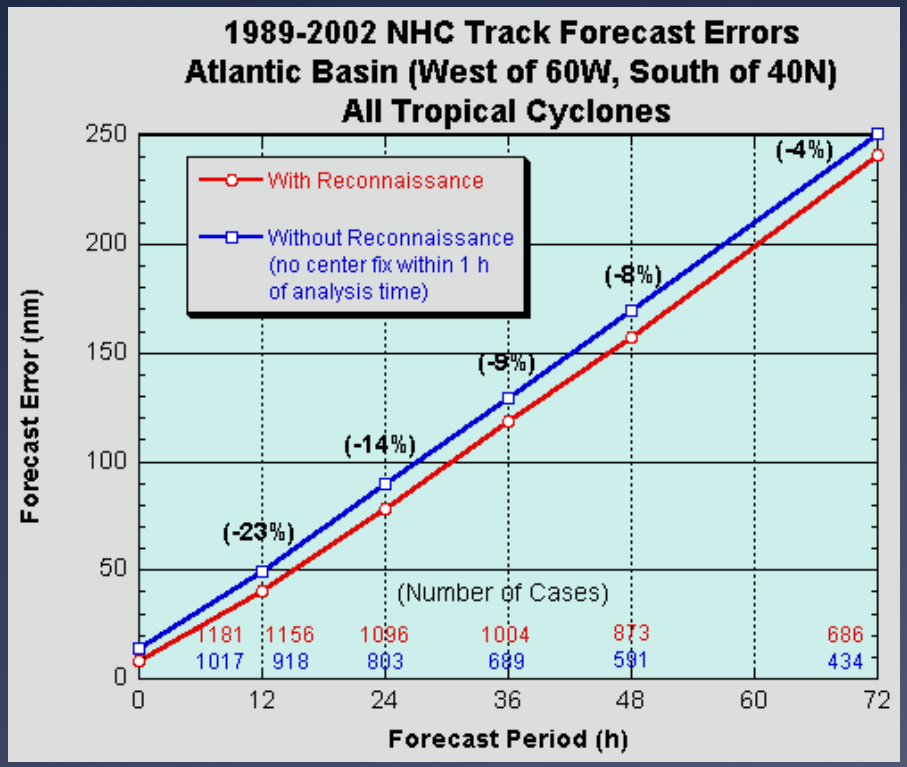


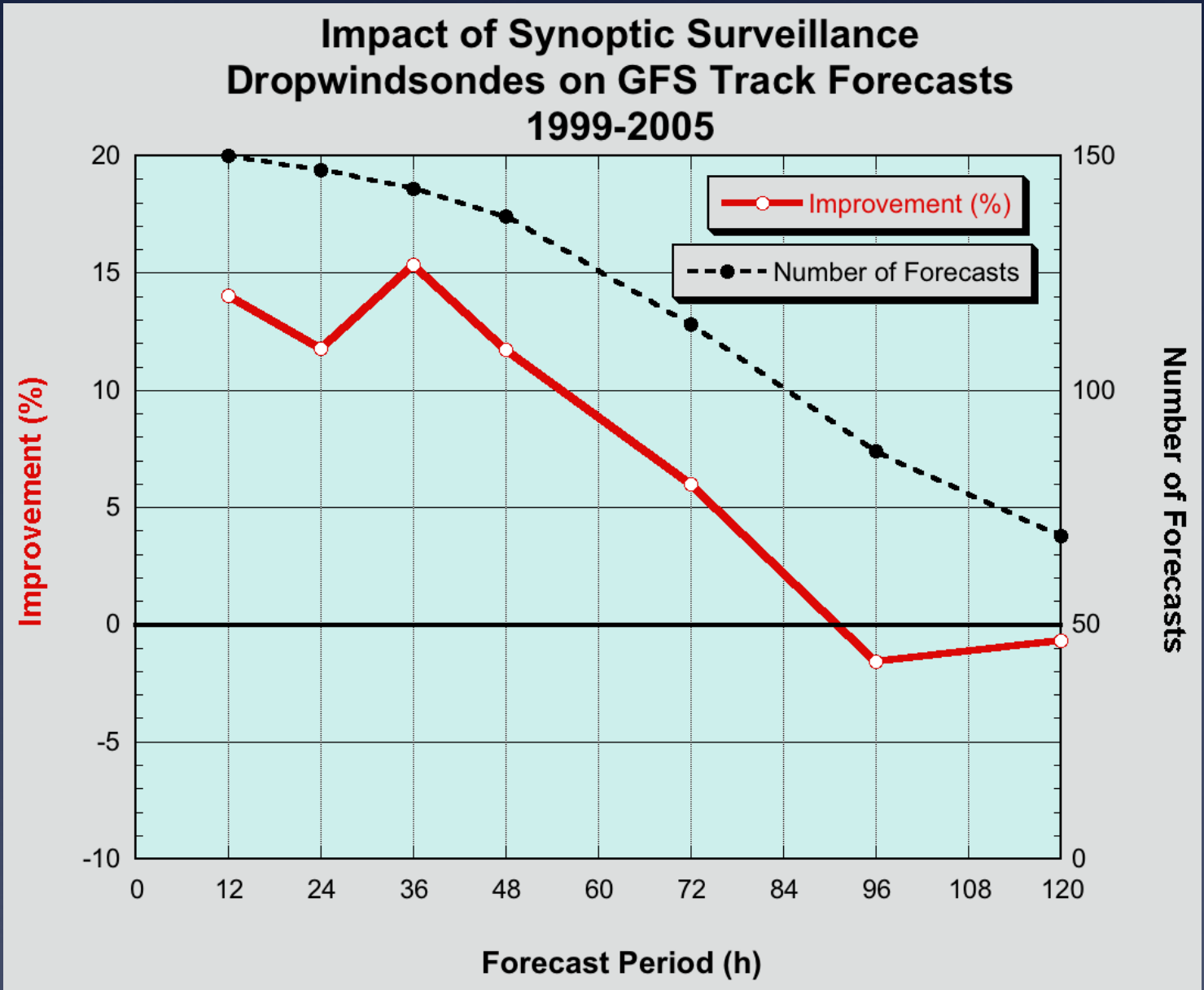
- Initial Intensity Accuracy
  - About ¼ of satellite intensity estimates are off by 10 mb or more.
  - About 12% are off by 1 SSHWS category.
  - About 2% are off by 2 SSHWS categories.

Why Do We Want Reconnaissance Data?

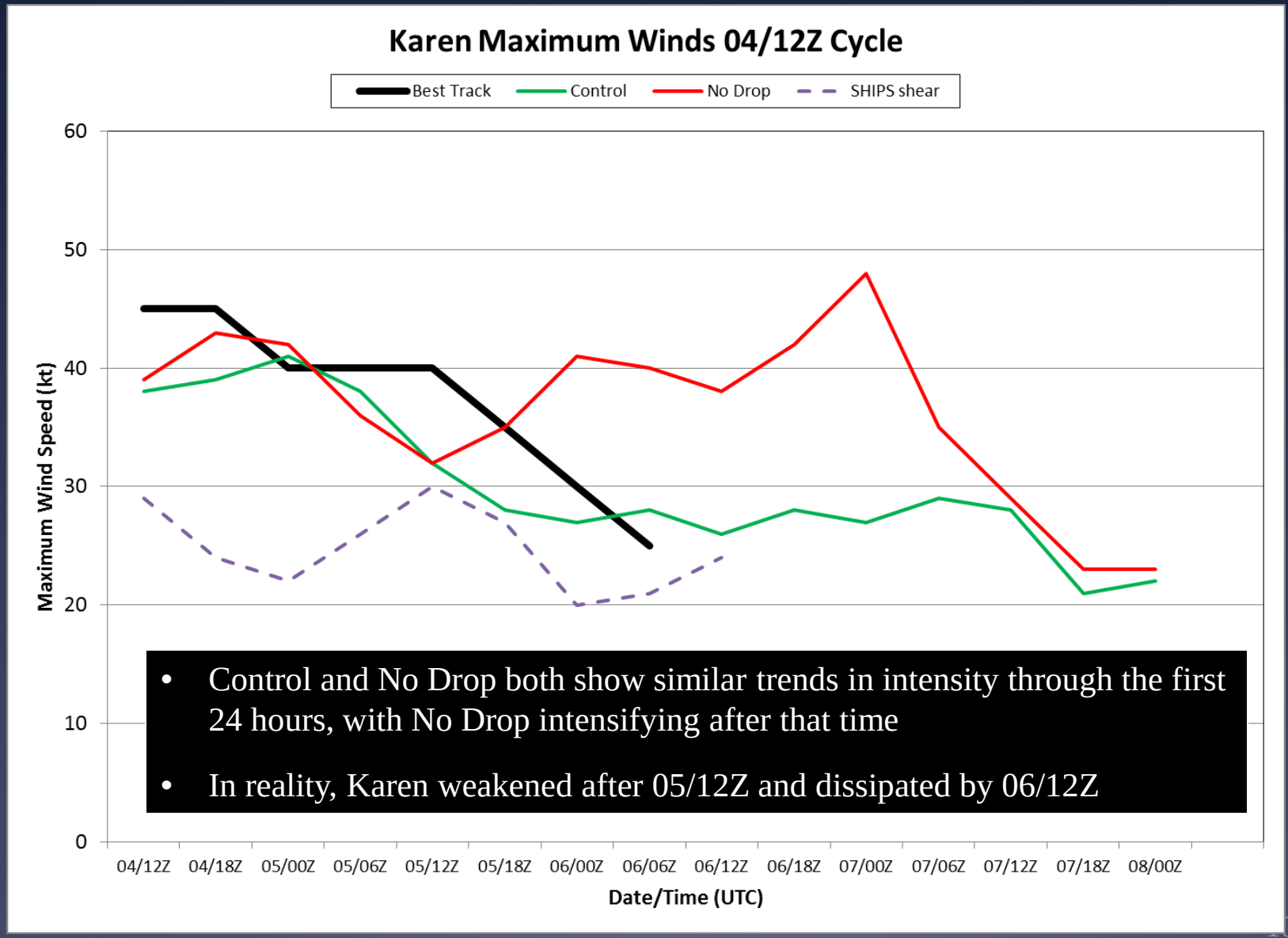


- Track Forecast Accuracy
  - Inner core reconnaissance improved 12 h forecasts by 23%.
  - Benefit persisted through 72h.
  - Unclear if this is still the case; the dataset is quite old.

1999-2005 Dropsonde Impact



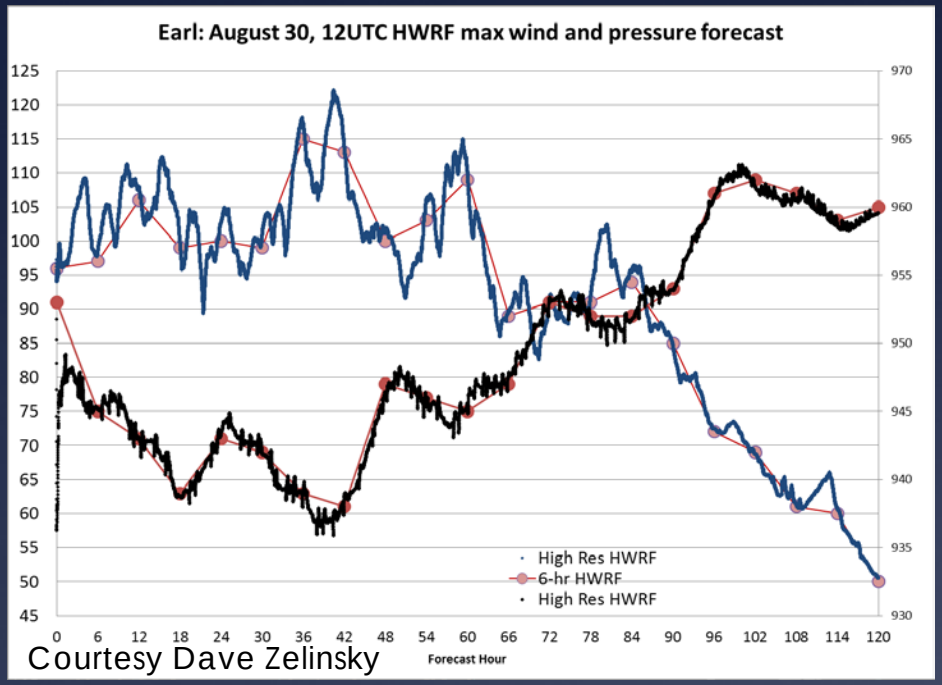
Karen Intensity – GFS Experiments

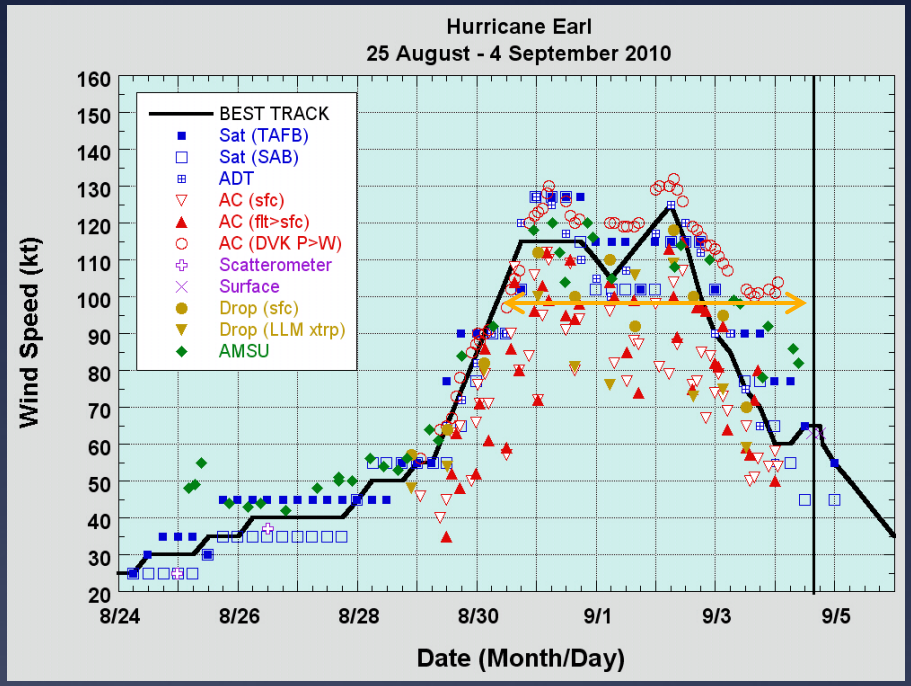


Tropical Cyclone Intensity

- Maximum sustained surface wind: When applied to a particular weather system, refers to the highest 1-min average wind (at an elevation of 10 m with an unobstructed exposure) associated with that weather system at a particular point in time. (NWSI 10-604)
- Intensity is not the highest 1-min wind that exists within the circulation.
  - Observations can be discounted if they are primarily associated with something other than the TC circulation (e.g., transients associated with short-lived convective downbursts, embedded tornadoes, squall lines, meso-cyclones, etc.
- Intensity is not the highest 1-min wind occurring over an interval of time. The advisory intensity should correspond to the expected value of the MSSW at advisory time.

Representative Intensity

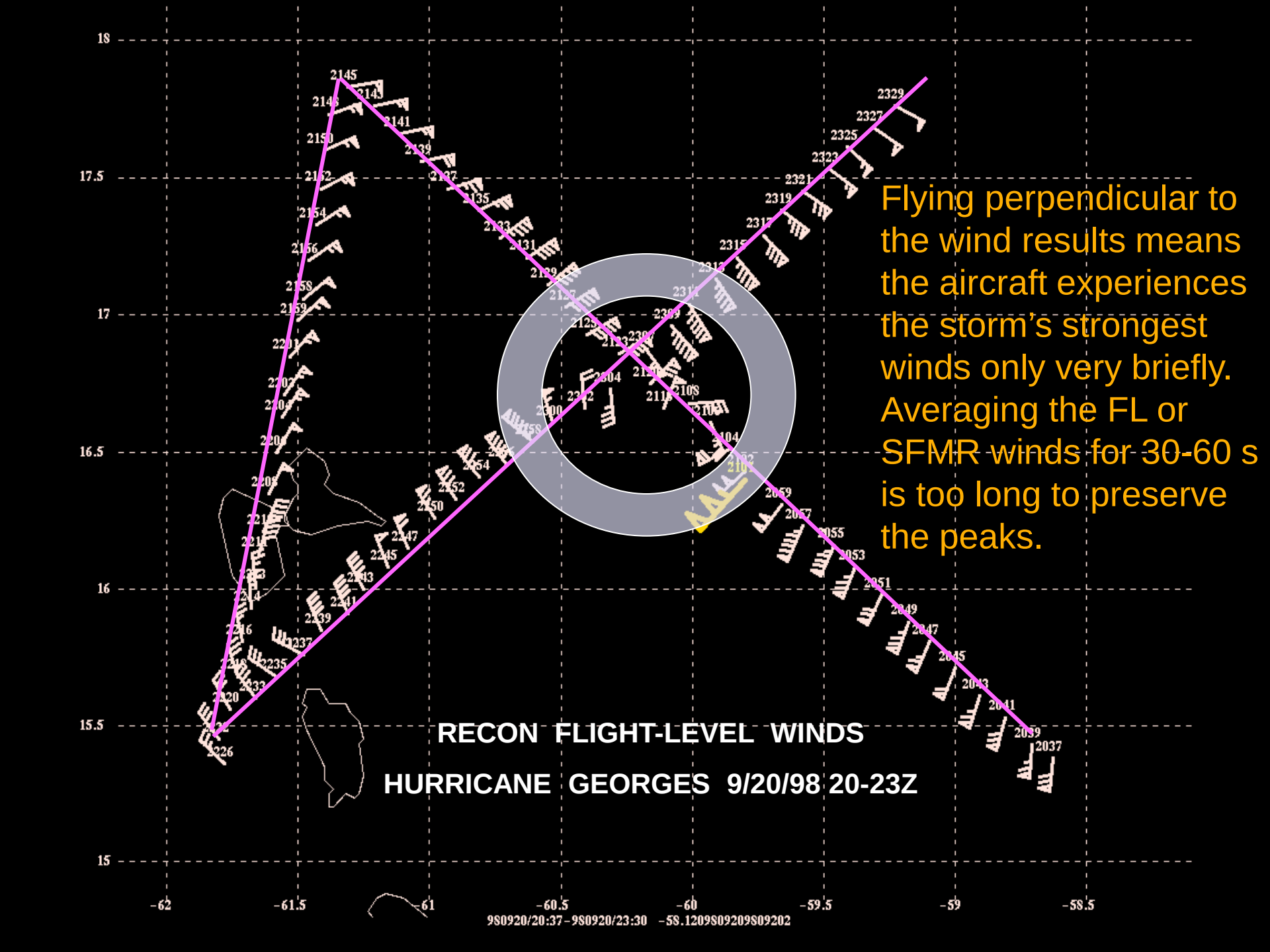




Peak winds in a model TC (blue curve in left diagram) can vary widely over periods of a few hours. Tracking these rapid changes for real storms is neither possible nor desirable.

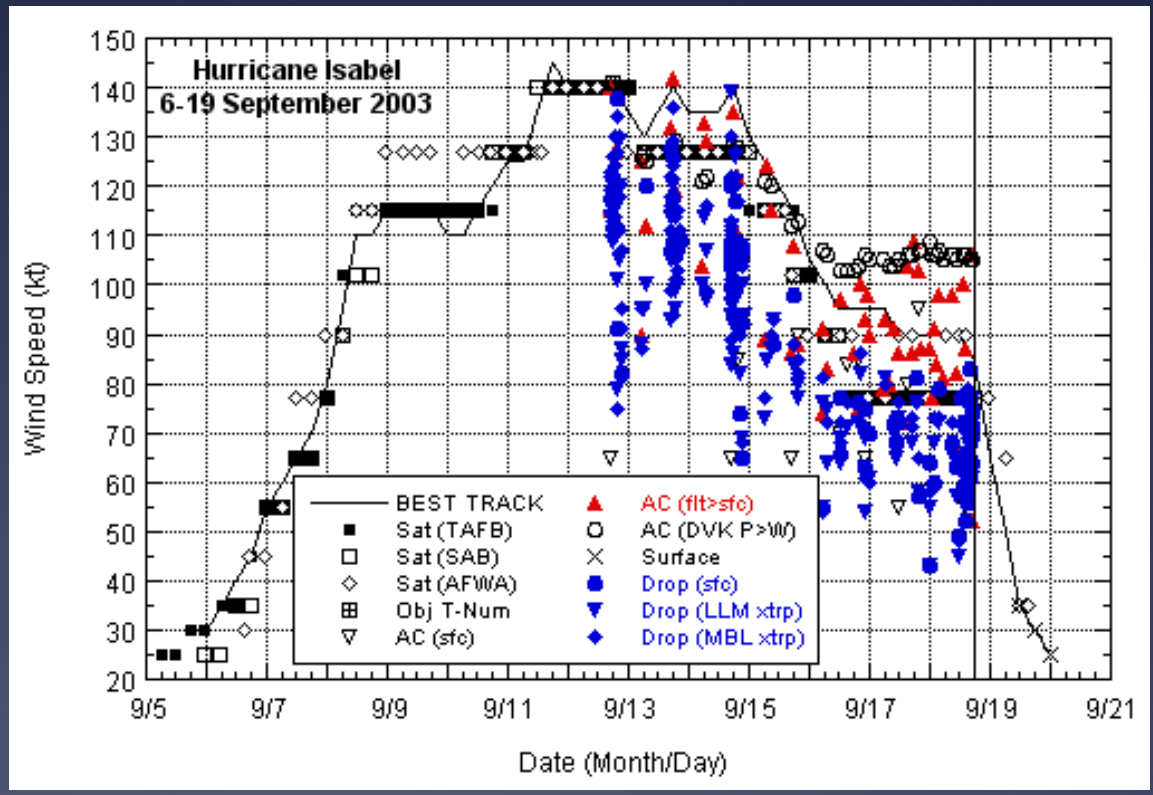
Best Track: Six-hourly representative estimates of the cyclone's center position, maximum sustained (1-min average) surface (10-m) wind, minimum sea level pressure, and maximum extent of 34-, 50-, and 64-kt winds in each of four quadrants around the center.

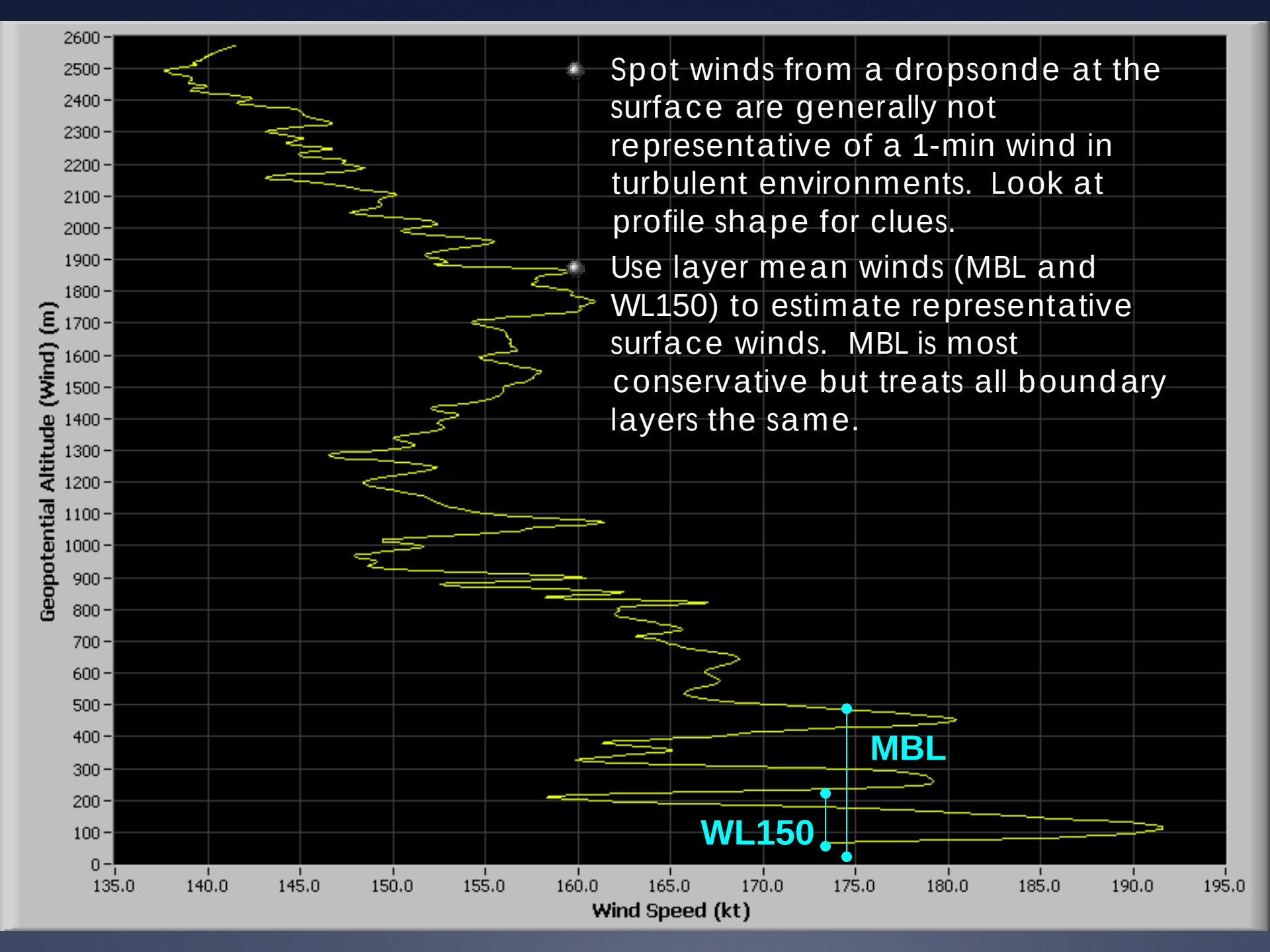
Best-track and operational intensity estimates attempt to smooth through the short-term fluctuations. NHC Hurricane Specialists have to use their judgment whether any particular observation is representative of the tropical cyclone or some transient feature, and balance representativeness against...


RECON FLIGHT-LEVEL WINDS
HURRICANE GEORGES 9/20/98 20-23Z
Flying perpendicular to the wind results means the aircraft experiences the storm's strongest winds only very briefly. Averaging the FL or SFMR winds for 30-60 s is too long to preserve the peaks.
18
17.5
17
16.5
16
15.5
15
-62
-61.5
-61
-60.5
-60
-59.5
-59
-58.5
9S0920/20:37-9S0920/23:30 -58.1209S09209S09202

Variability of Standard Adjustment

- SFC:700 mb wind ratios vary from storm to storm, and can range from ~70% to >100%. But departures from standard adjustment cannot be determined from just a few sondes.
  - Convective vigor
  - Eyewall structure, cycle, RMW
  - Low-level stability/cooler waters



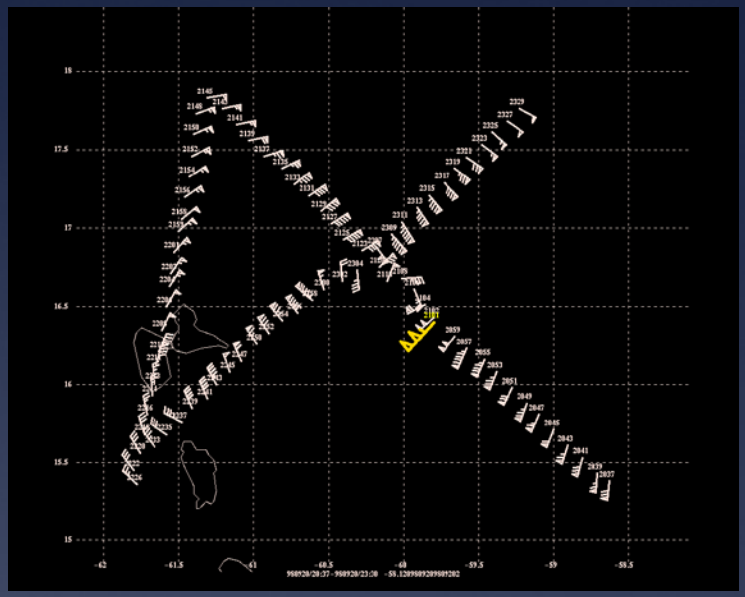

Spot winds from a dropsonde at the surface are generally not representative of a 1-min wind in turbulent environments. Look at profile shape for clues.
Use layer mean winds (MBL and WL150) to estimate representative surface winds. MBL is most conservative but treats all boundary layers the same.
MBL
WL150
Geopotential Altitude (Wind) (m)
Wind Speed (kt)
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
135.0
140.0
145.0
150.0
155.0
160.0
165.0
170.0
175.0
180.0
185.0
190.0
195.0

SFMR Issues

- Shoaling – breaking waves in areas of shallow water artificially increase retrieved winds (issue in the Bahamas).
- Interaction of wind and wave fields can introduce azimuthally dependent errors ~5 kt.
- Rain impacts at TD/TS wind speeds remain.
- Calibration seems to be a never-ending process

Gaps/Future Needs

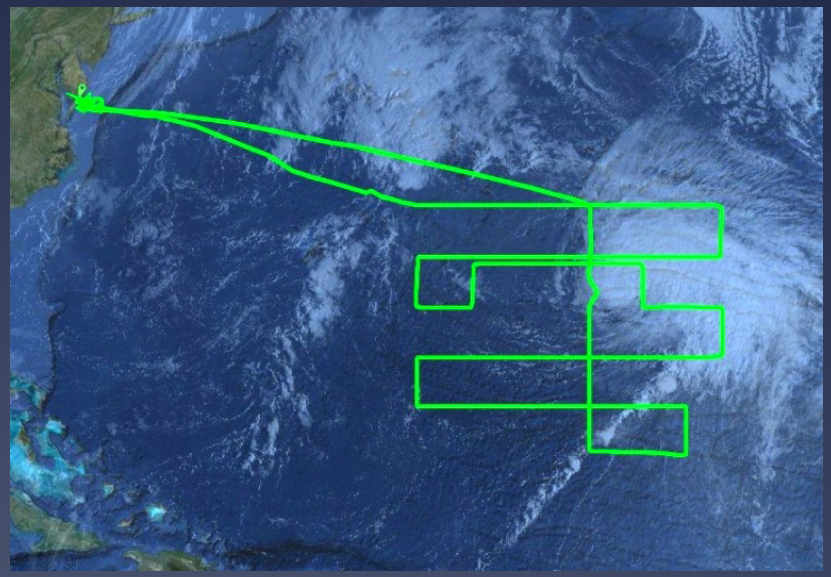
* NHOP: Surface center, continuous SST.
* Despite the relative speed of today's heavy aircraft, only a small fraction of the storm circulation is currently sampled.
* Improved temporal and spatial resolution of the eyewall, primarily for forecaster use, so that we can better assess undersampling/ representativeness issues.
* Three-dimensional depiction of wind (including where there are no scatterers), temperature, and humidity fields for model initialization and forecaster interpretation.



* HIRAD swaths for wider surface winds
* Combined Doppler/Lidar
* Thermodynamics??

Unmanned Aircraft

- Long-endurance high-altitude aircraft could perform surveillance-type missions for more remote systems, although their slow speed places stresses on a model's data assimilation system.
- Similar missions could potentially improve model genesis forecasts.



Unmanned Aircraft

- NHC has had limited enthusiasm for unmanned aircraft.
  - They're slow (G-IV ~30% faster than Global Hawk)
  - Cannot survey a storm in a reasonable period of time.
  - Could have specialized operational function if they can continuously monitor a specific area (e.g., RMW).

Intangibles/Indirect Benefits of NOAA Heavy Aircraft

- Large heavy aircraft have served as an invaluable testbed for future operational applications
  - ODW deployments provided justification for the G-IV and GPS sondes.
  - SFMR
  - Doppler radar (not yet transitioned but semi-operational).
- A platform for research by NOAA partners that lead to improved operational products (Ocean Winds).
- Hurricane Awareness Tour
- But it's not enough to put great tools on NOAA aircraft because there aren't enough of them. *Advances must make their way to the entire reconnaissance fleet.*