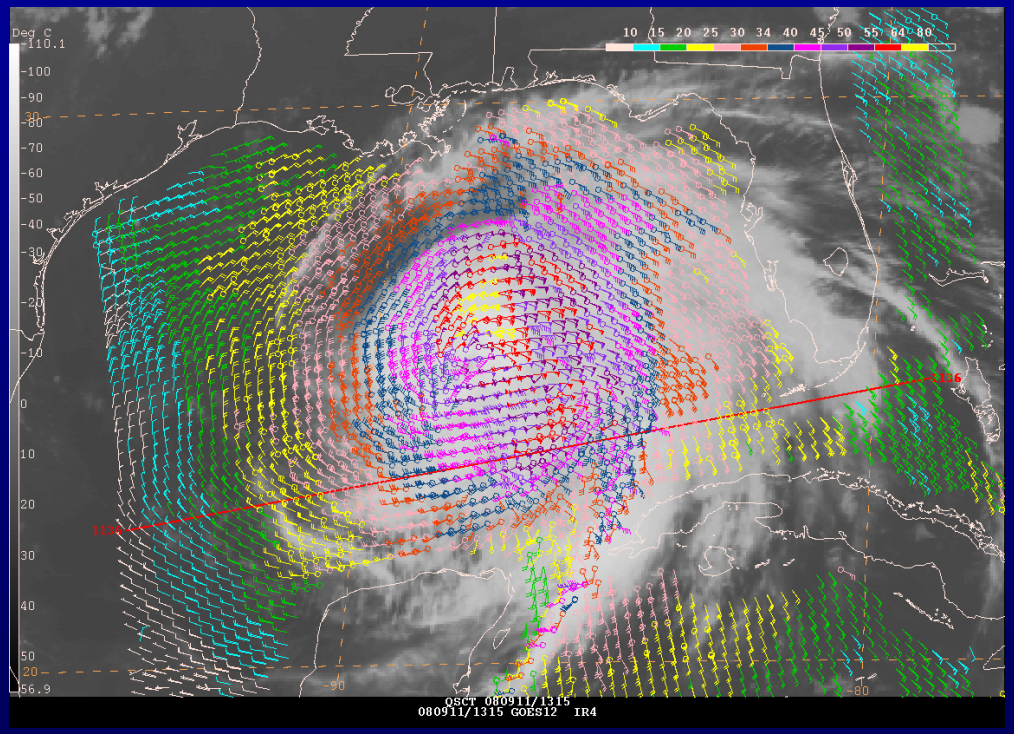
Global Monitoring of Tropical Cyclones with a Dual-Frequency Scatterometer



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Workshop on Scatterometry and ClimateArlington, Virginia 19 August 2009

Hurricanes and Climate: Why So Important?

- Long-term changes in hurricane frequency, intensities, and durations, depending on their existence and magnitude, could have significant societal ramifications worldwide due to direct impacts

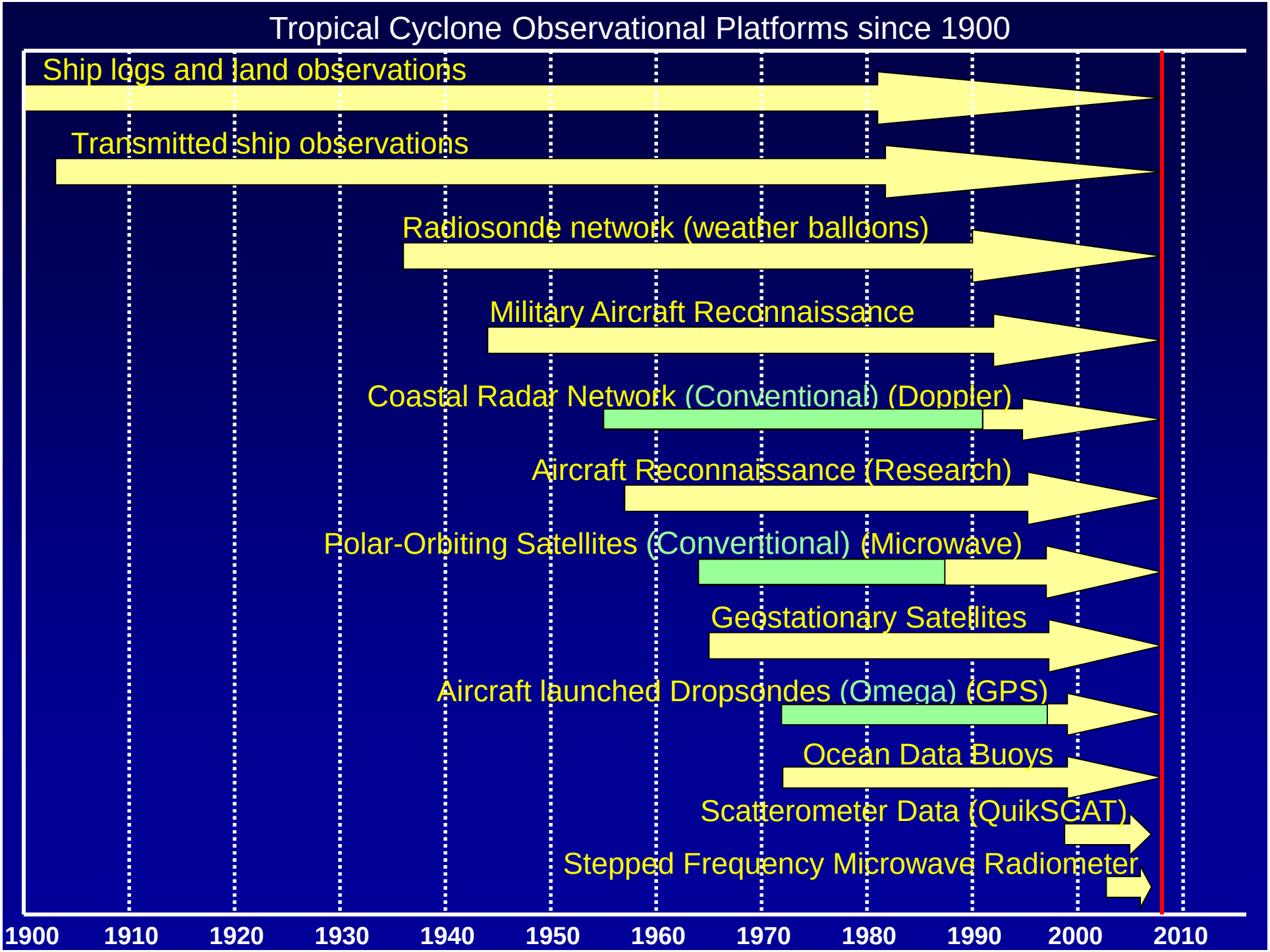
- Tropical cyclones play a key role in the global energy and moisture budget, so changes in their intensities and durations could be significant

- Tropical cyclone intensity change is our #1 forecast improvement need, and requires accurate climatology

Hurricanes and Climate: Challenges

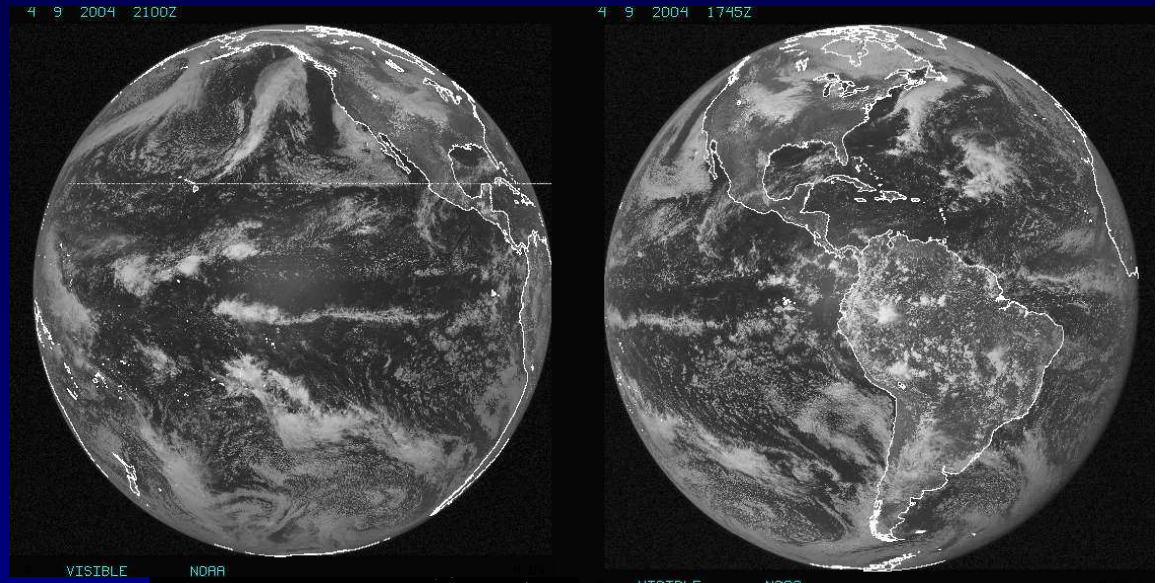
- The ongoing historical data record is insufficient for identifying long-term changes in global hurricane intensities and durations

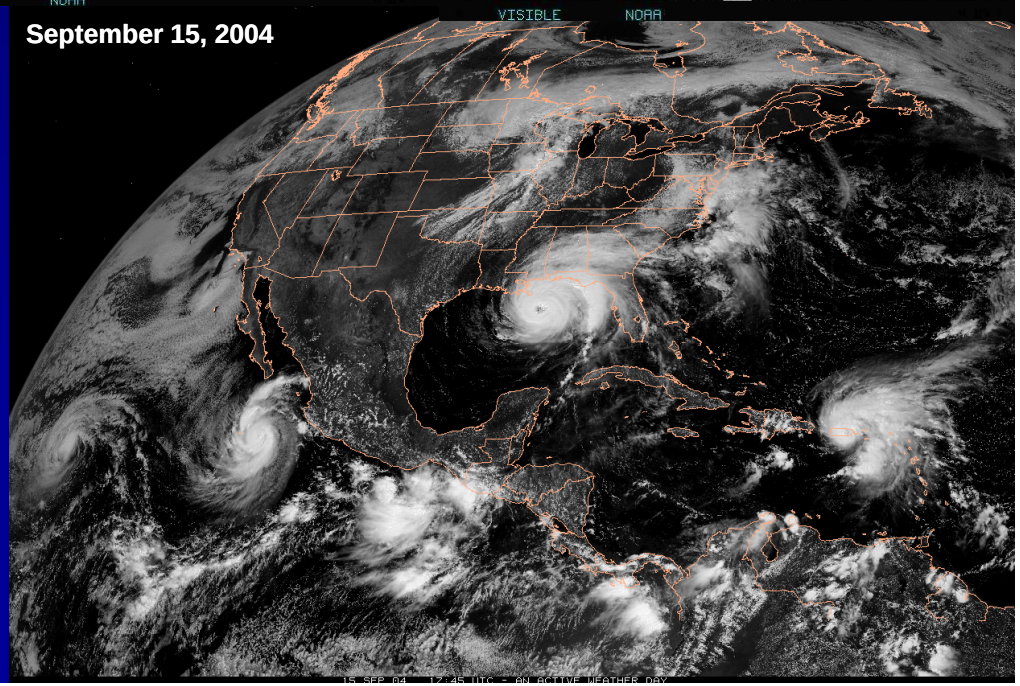
- Difficult to improve forecasts on tropical cyclone intensity and structure, when those parameters are so often inaccurately observed


Tropical Cyclone Observational Platforms since 1900
Ship logs and land observations
Transmitted ship observations
Radiosonde network (weather balloons)
Military Aircraft Reconnaissance
Coastal Radar Network (Conventional) (Doppler)
Aircraft Reconnaissance (Research)
Polar-Orbiting Satellites (Conventional) (Microwave)
Geostationary Satellites
Aircraft launched Dropsondes (Omega) (GPS)
Ocean Data Buoys
Scatterometer Data (QuikSCAT)
Stepped Frequency Microwave Radiometer
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Geostationary Satellites

- **Best data source to monitor tropical cyclones on a nearly continuous basis**
- **In most of the world's tropical cyclone basins, most of the time, it's the only data source**

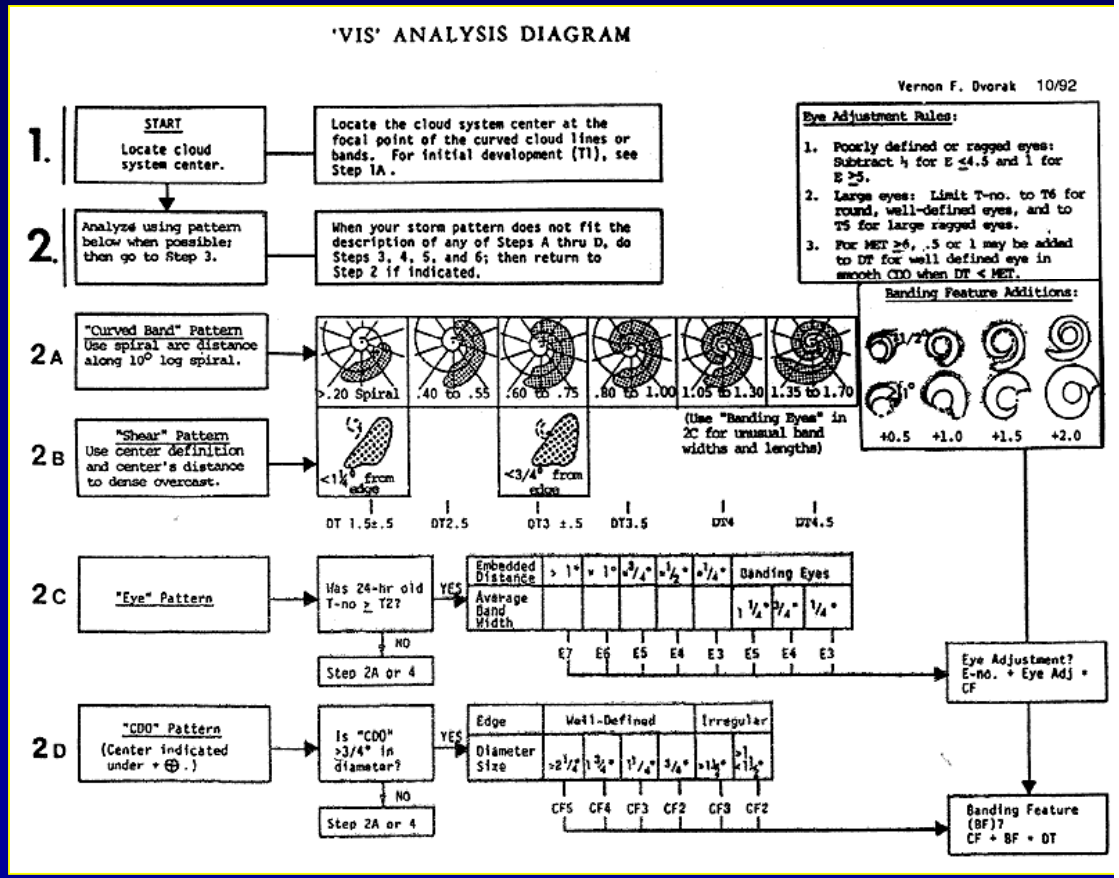


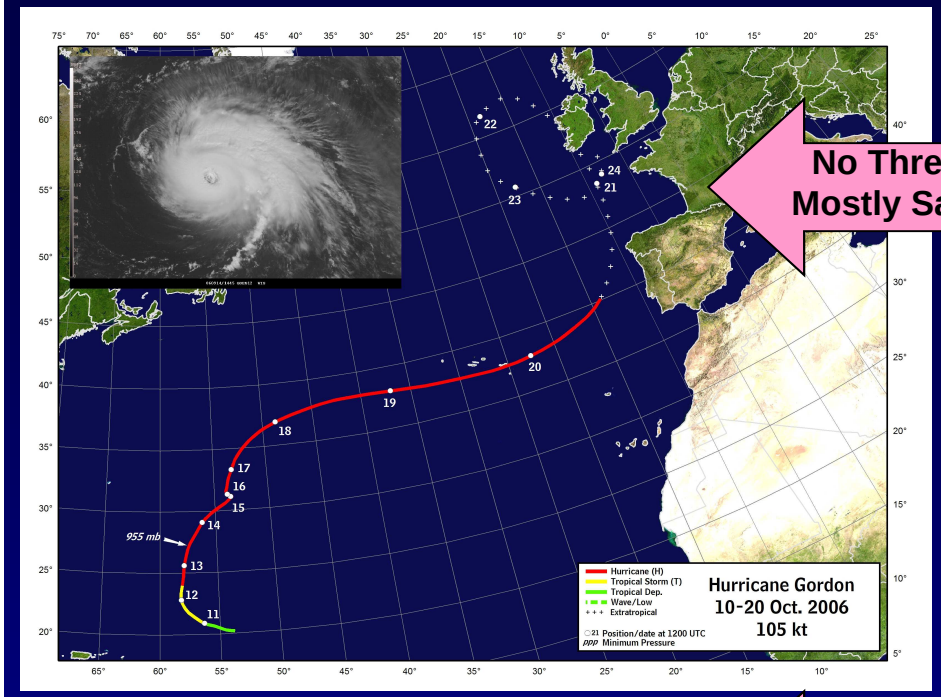


The Dvorak Technique

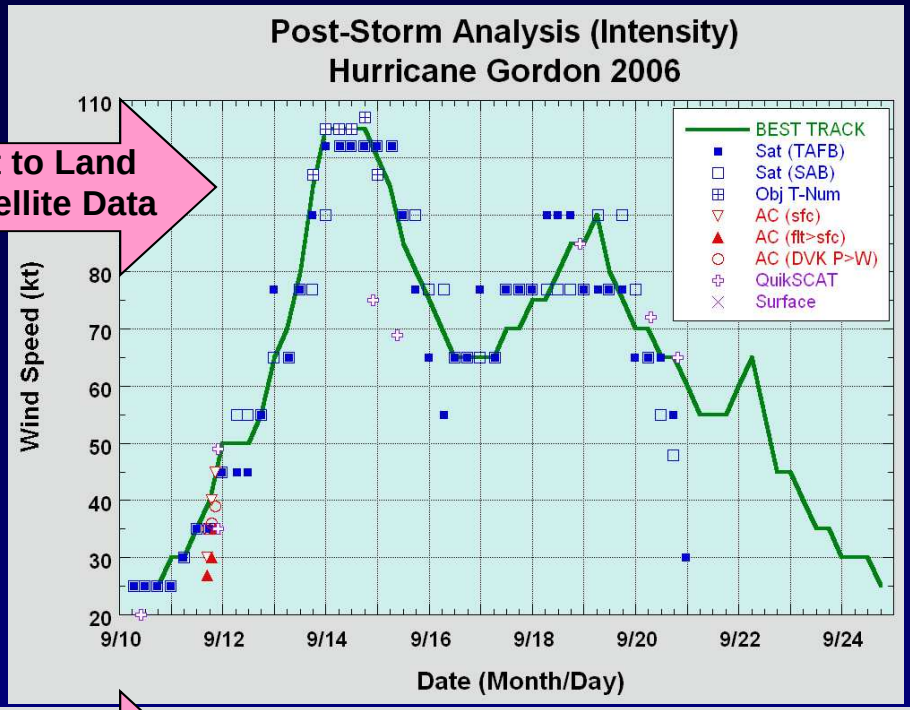
- A statistical method for estimating the intensity of TCs from satellite imagery
- Uses infrared and visible imagery
- Uses “measurement” of the TC cloud pattern and a set of rules
- Comes in manual and automated versions
- Related technique for subtropical cyclones

Dvorak Technique Cloud Patterns

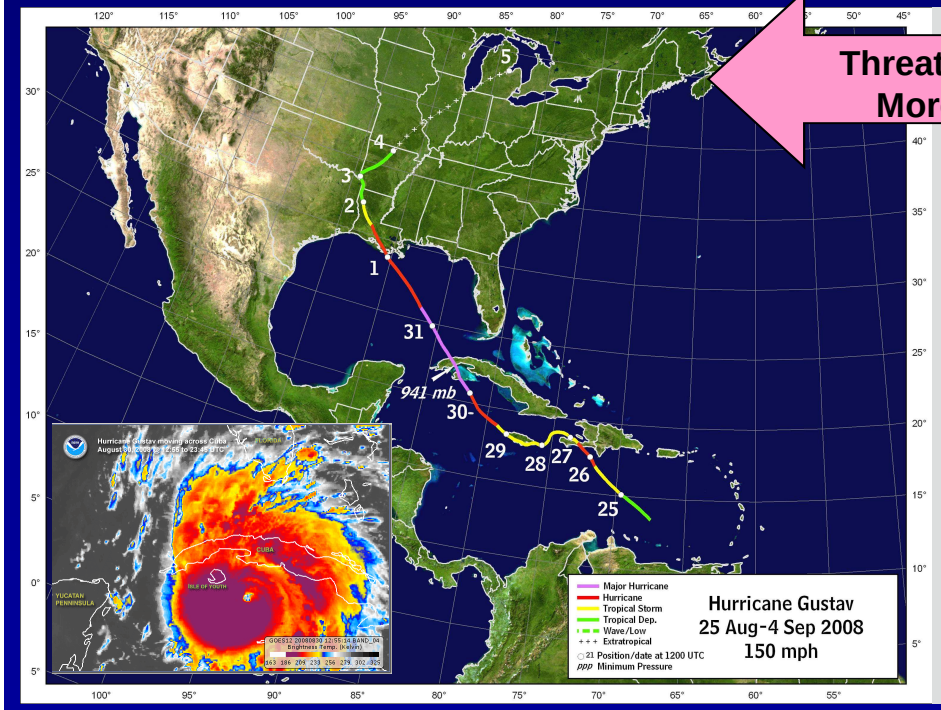


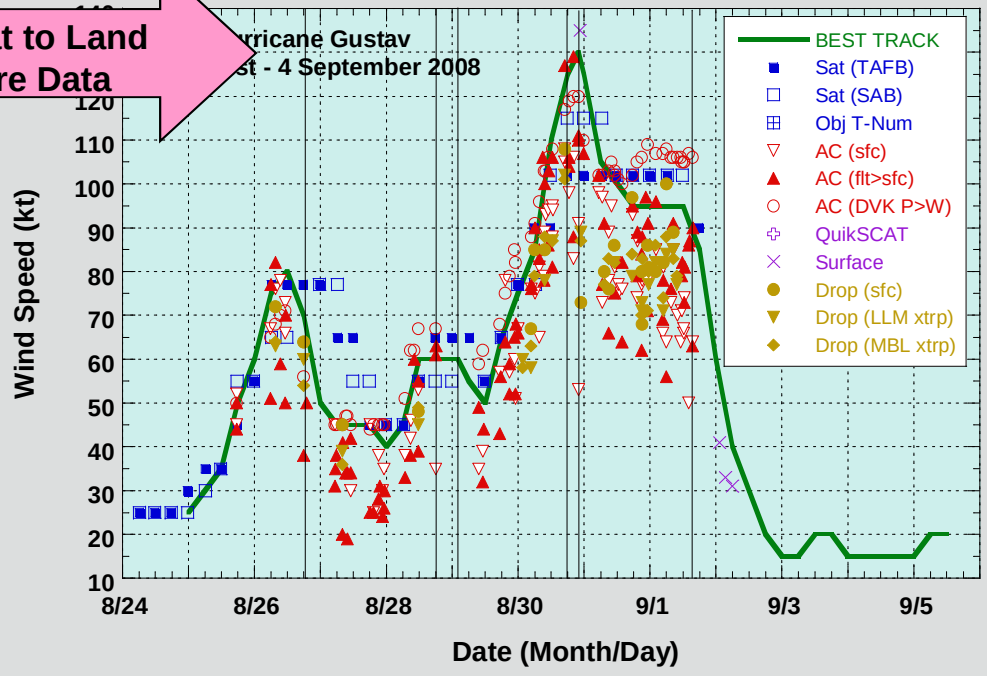


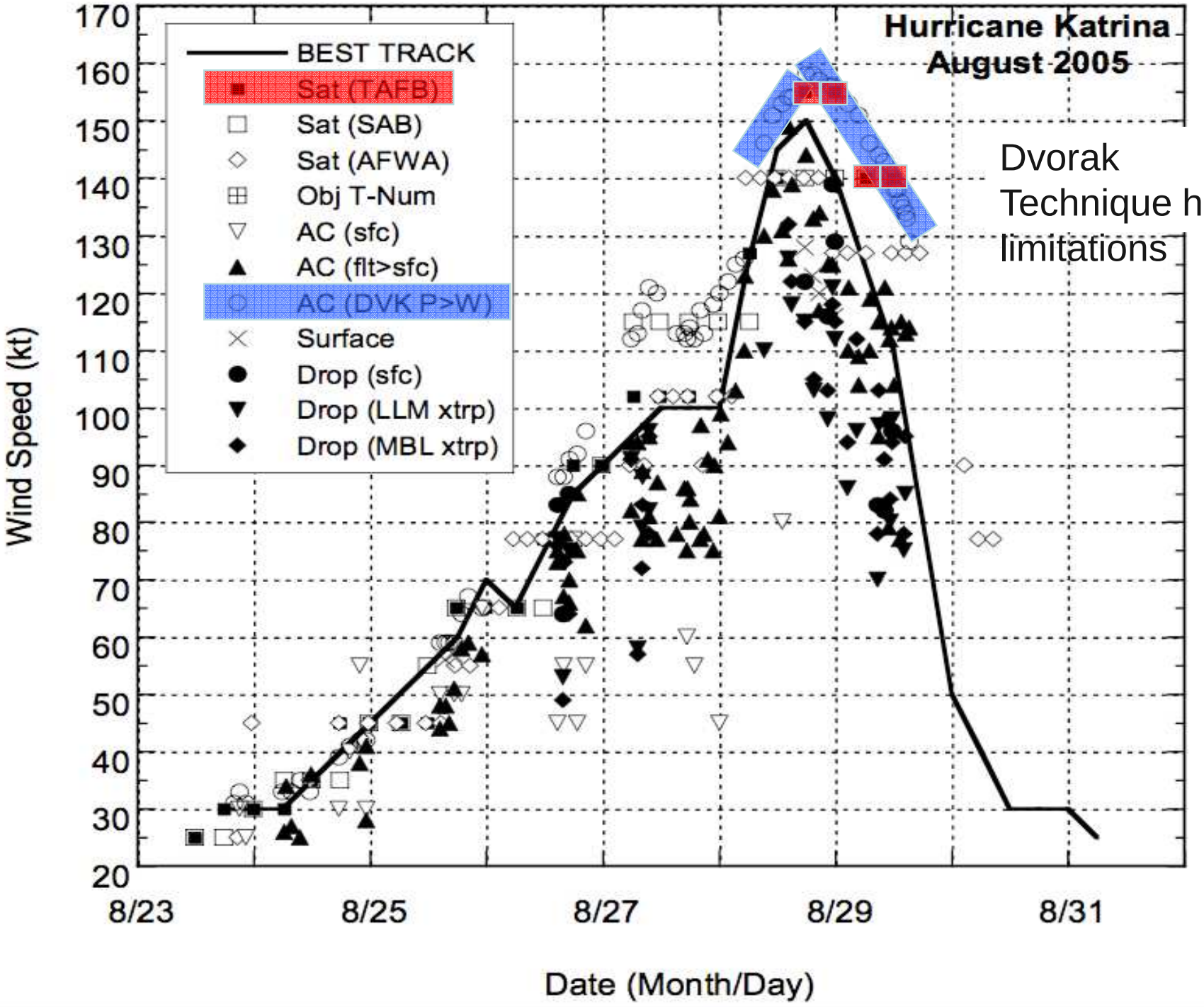
No Threat to Land
Mostly Satellite Data



Threat to Land
More Data



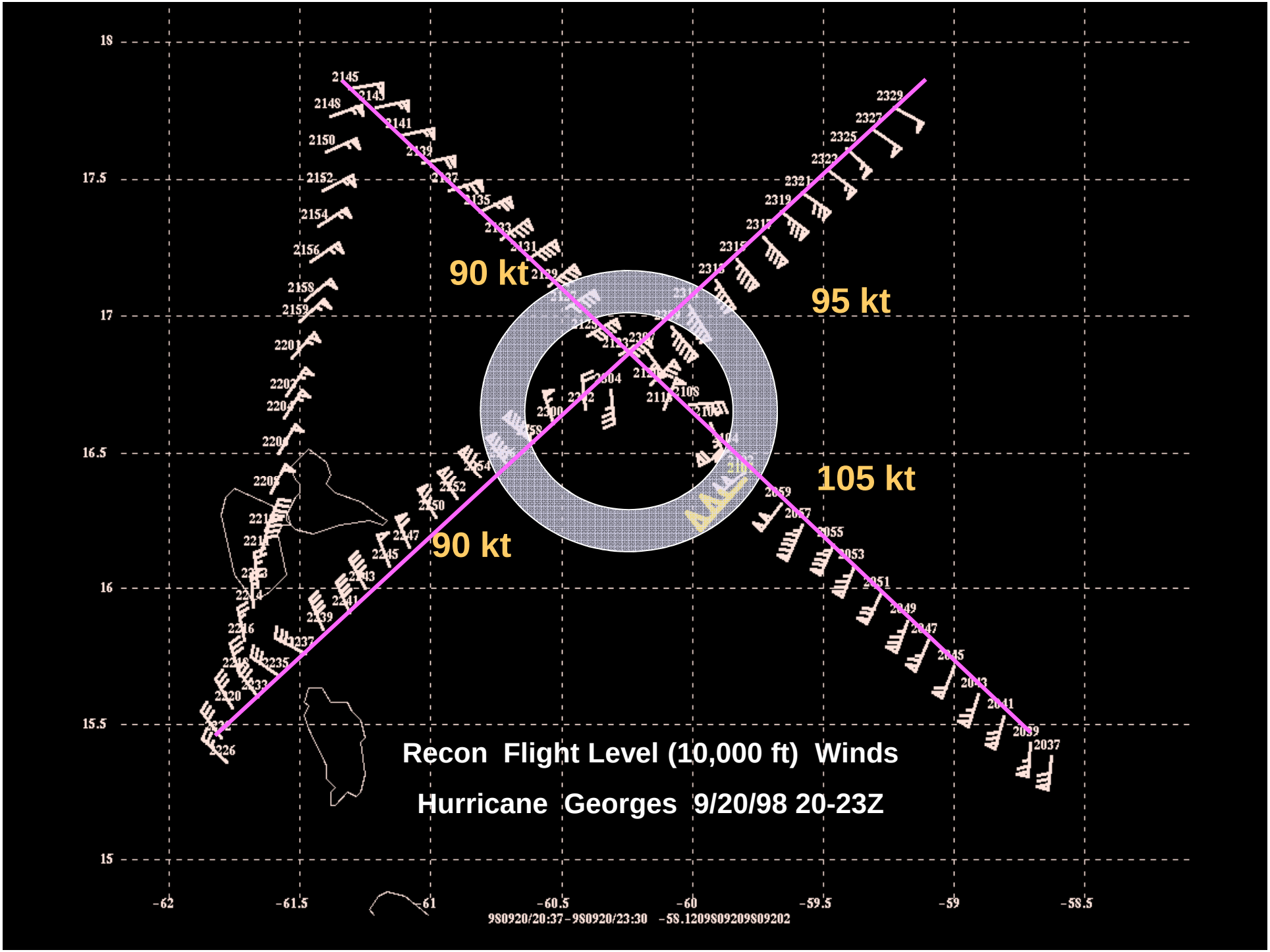




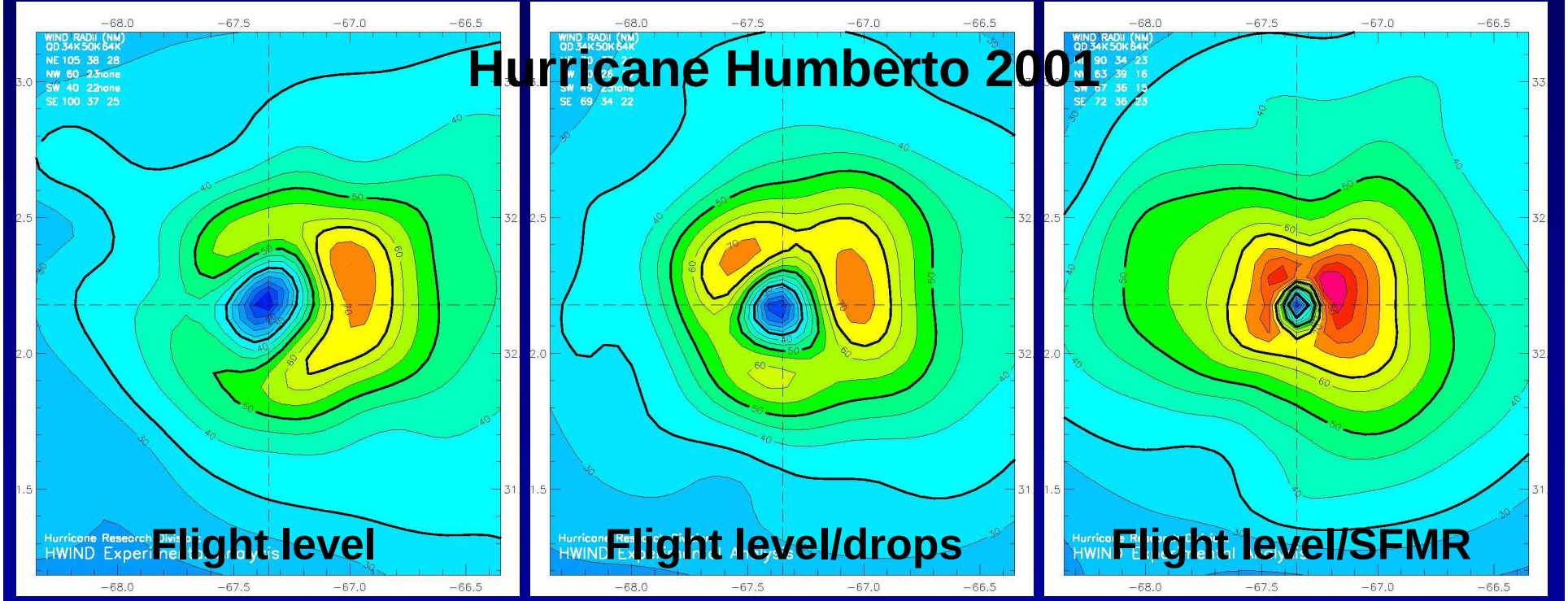
Dvorak Technique has limitations

U.S. Aircraft Reconnaissance

- Available when a TC threatens land, but only in western Atlantic, far eastern Pacific, and central Pacific basins
- Location of circulation center, and minimum pressure
- Flight-level winds (along line)
- GPS dropsonde profiles (single spot vertical profiles)
- Stepped-Frequency Microwave Radiometer (SFMR; surface wind speed retrievals along line)
- Airborne doppler radar

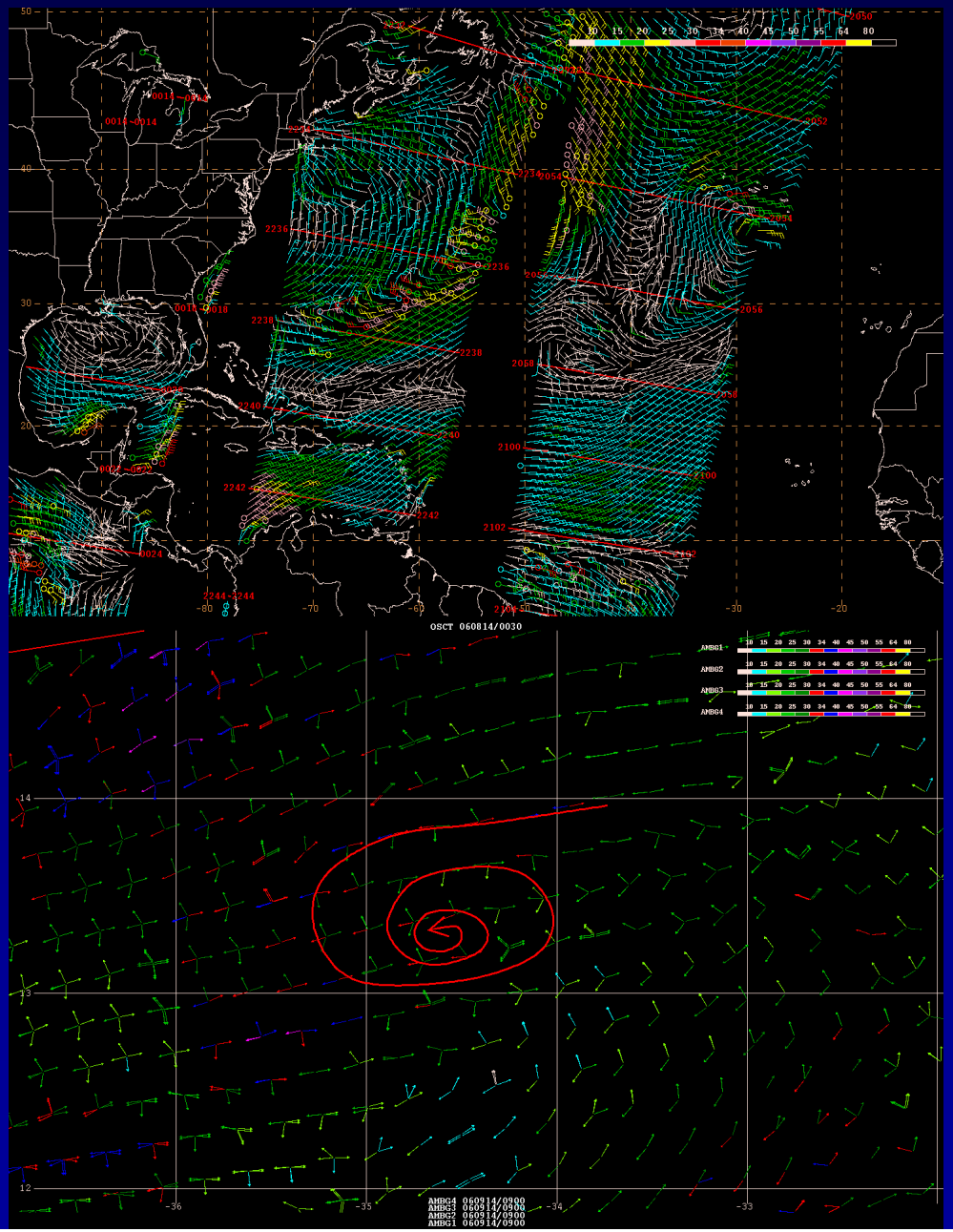

90 kt
95 kt
105 kt
90 kt
Recon Flight Level (10,000 ft) Winds
Hurricane Georges 9/20/98 20-23Z
980920/20:37-980920/23:30 -58.1209809209809202

TC intensity and structure determination heavily dependent upon available data



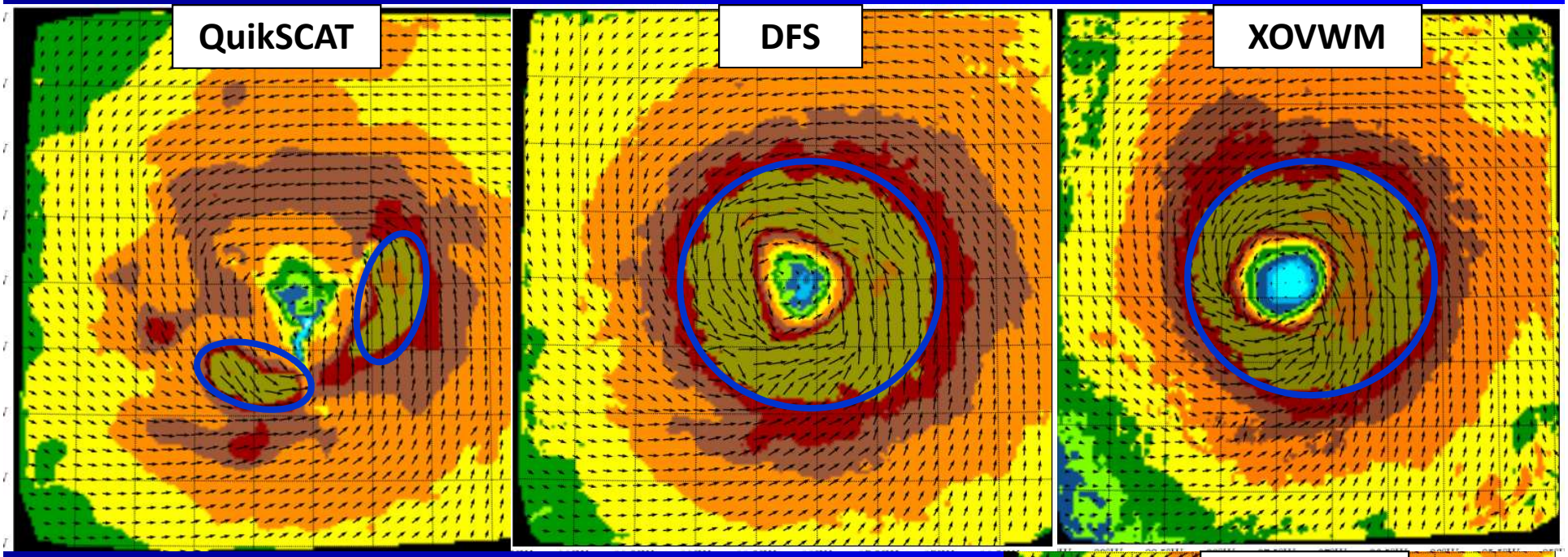
QuikSCAT Limitations in TCs

- At most two passes a day at low and mid-latitudes
- Gaps between swaths approach 1000 km in deep Tropics
- Sensitive to rain → problem in TCs and elsewhere
- Can't measure maximum wind in most hurricanes
  - Resolution, instrument design, rain effects
- Directional uncertainty limits ability to identify or locate TC centers
  - Subjective analysis of "ambiguities" by forecaster required
- The unavailability of data near shore

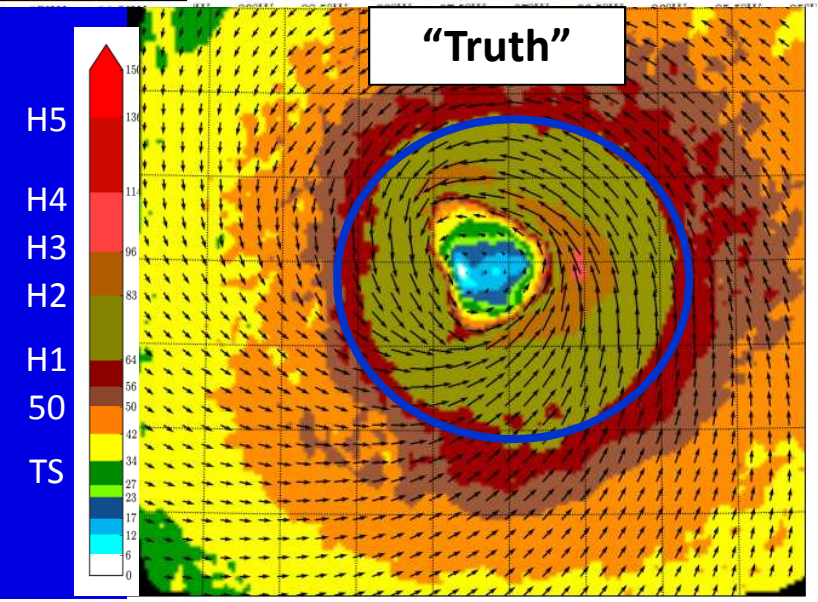


DFS vs. QuikSCAT and XOWVM

Simulated Retrievals based on Katrina (2005)



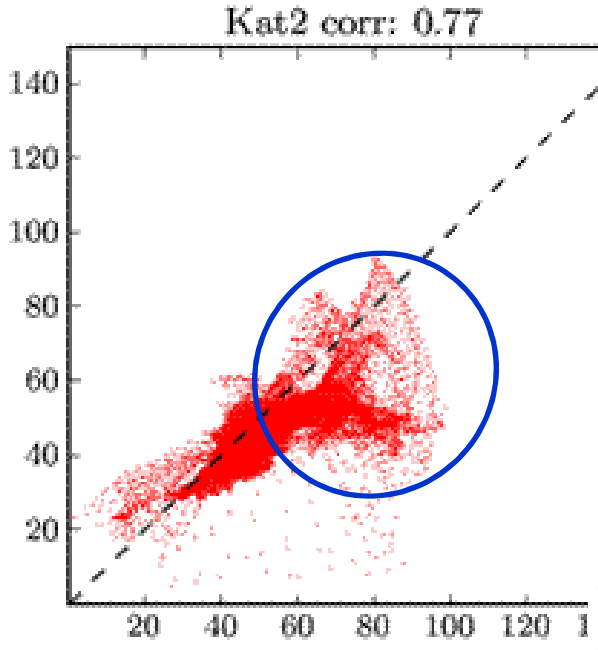
- DFS captures true wind signal where QuikSCAT high winds are tied to rain
- DFS accurately depicts hurricane force wind radii and retrieves winds into category 2 range, but not into cat 3 range
- DFS cannot identify small scale wind maxima seen by XOVWM



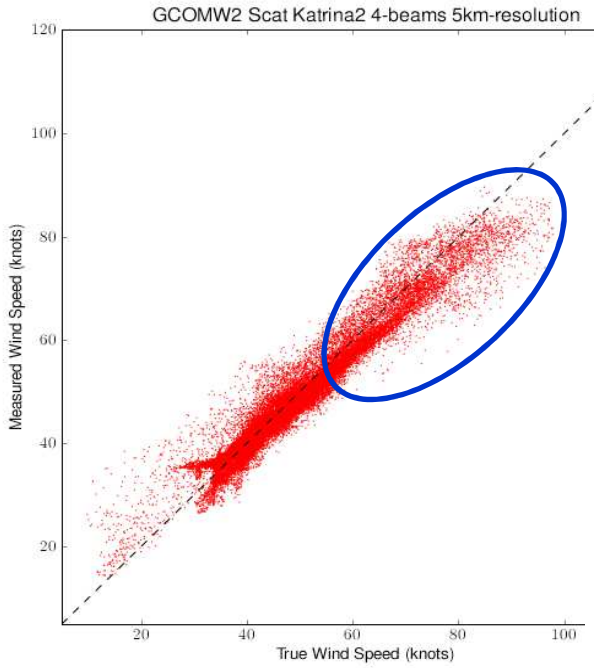
DFS vs. QuikSCAT and XOWVM

Katrina Simulated Retrievals

QuikSCAT

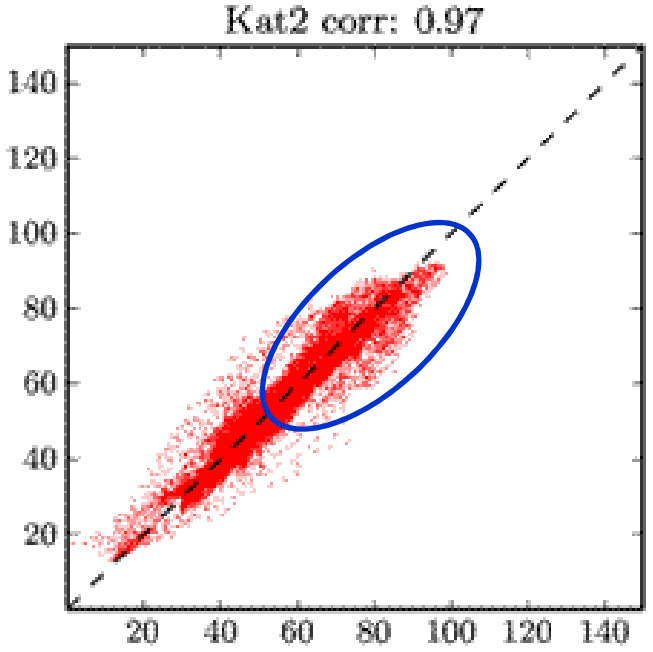


DFS



- DFS captures true wind signal well into hurricane-force range
- DFS shows underestimation of winds ≥ 80-85 kt (not seen in XOVWM)
- Significant improvement over QuikSCAT

XOVWM



Retrieved Wind Speed

"True" Wind from WRF simulations

Summary: Data Limitations

- Geostationary satellite imagery indispensible for monitoring TCs worldwide, but Dvorak Technique for intensity estimation has limitations
- Aircraft data availability extremely limited, and even when available, suffer from severe sampling limitations
- QuikSCAT provides broad swath of surface wind data over many TCs, but has almost no utility for hurricane intensity, and requires manual interpretation to identify a TC's closed circulation

Summary: Benefits of DFS

- DFS would reliably measure a broad swath of surface winds in TCs, including intensities and structures of many hurricanes (although not most major hurricanes), and circulation centers of developing TCs
- One DFS would have same sampling limitations as QuikSCAT due to polar-orbiting platform
- DFS would be a critical new tool in the box for developing more accurate climatologies of TC intensities, structures, and durations worldwide, especially when aircraft reconnaissance not available
- Addition of DFS would offer huge benefits for monitoring hurricane and climate relationships, and for improving forecasts of TC intensity and structure