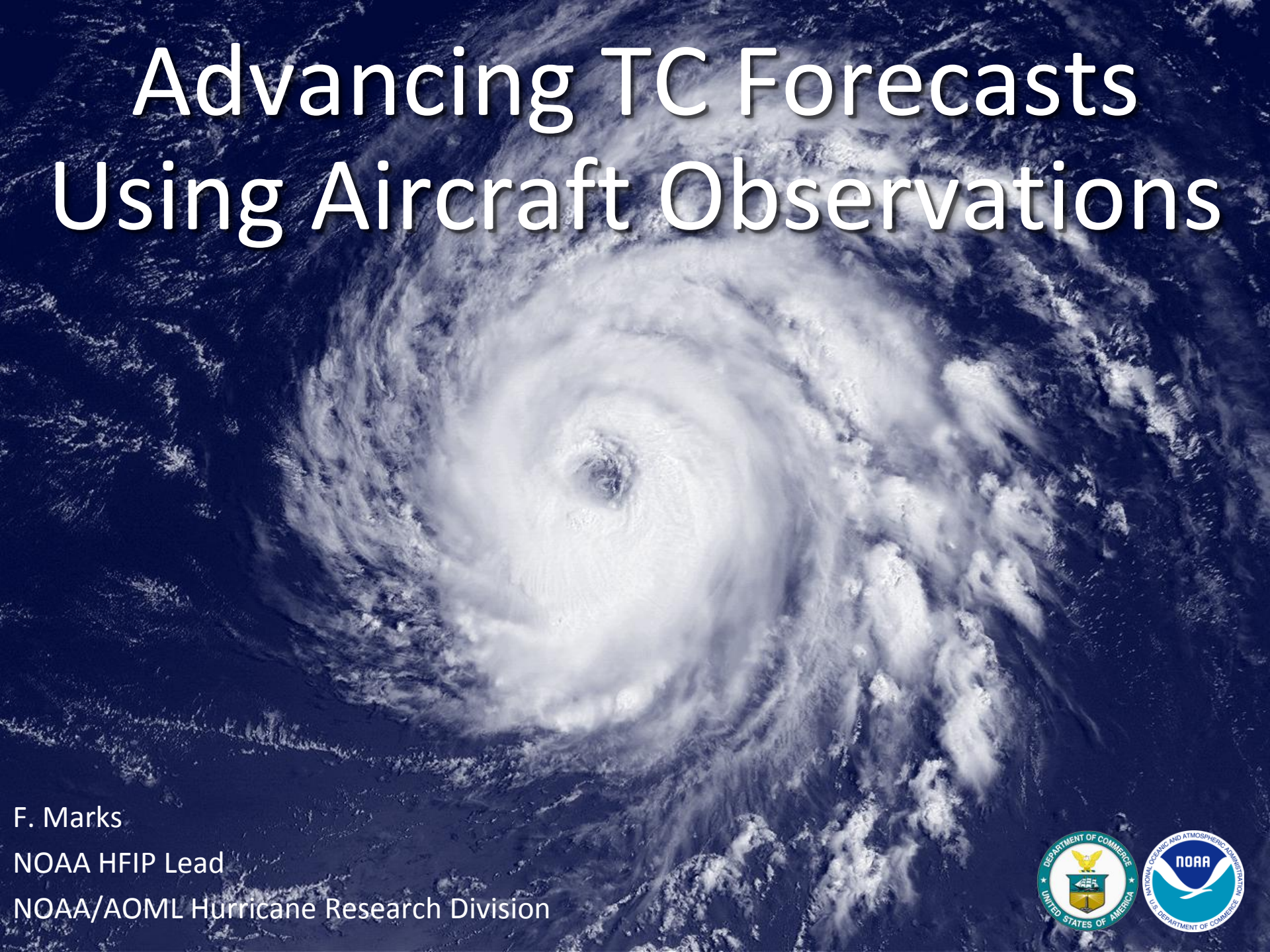
Advancing TC Forecasts Using Aircraft Observations

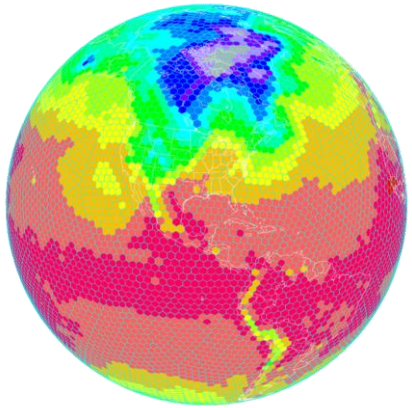


F. Marks
NOAA HFIP Lead
NOAA/AOML Hurricane Research Division

HFIP Activities

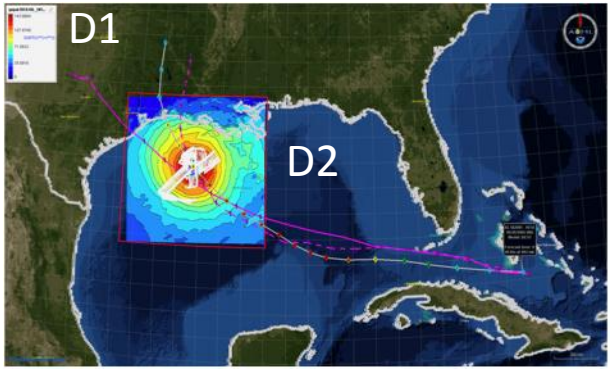
Traditional Hurricane Research Activities:

- Observations, analysis, database, & instrument R&D
- Statistical-dynamical model development
- Advances in operational models



New HFIP Research Thrusts:

- Experimental global and regional hurricane model development
- Data assimilation techniques and observing system strategy analysis development
- Model evaluation tool development
- Socioeconomic research and development



Partnership: NCEP, AOC, AOML, ESRL, GFDL, DTC, USWRP, NESDIS/STAR

Improved Use of Observations:

Intensity Forecast experiment (IFEX)

In-situ

- Wind, press., temp.

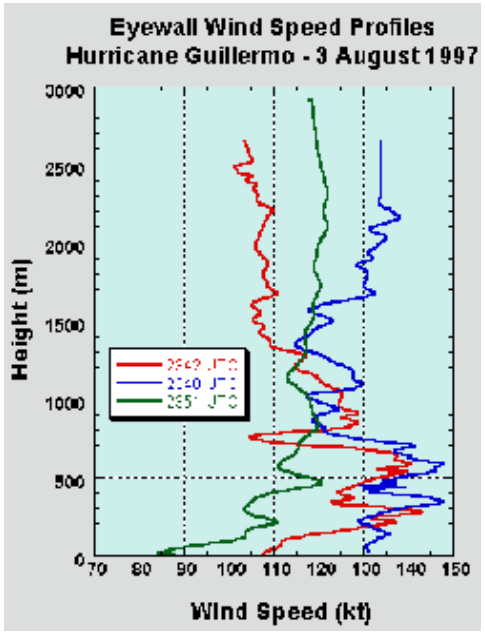
Expendables

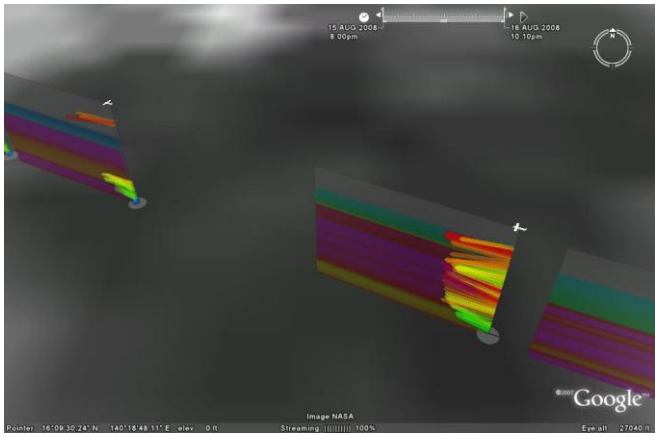
- Dropsondes
- AXBT, AXCP, buoy

Remote Sensors

- Doppler Radar
- SFMR
- DWL (ONR)
- WSRA
- Scatterometer/ profiler
- UAS

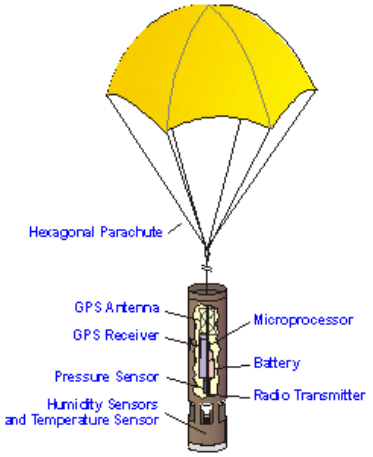
Coyote UAS

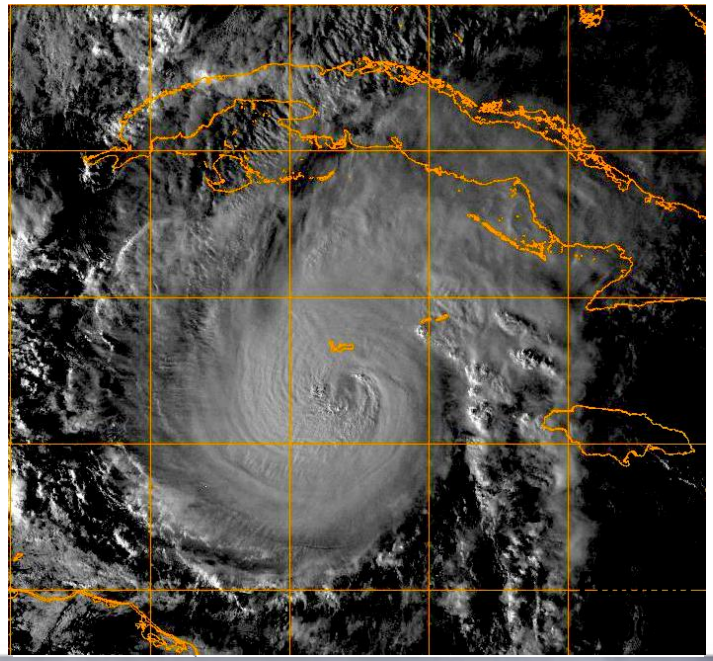




Improved Use of Observations:
Large-scale

- Synoptic-surveillance using dropsondes.

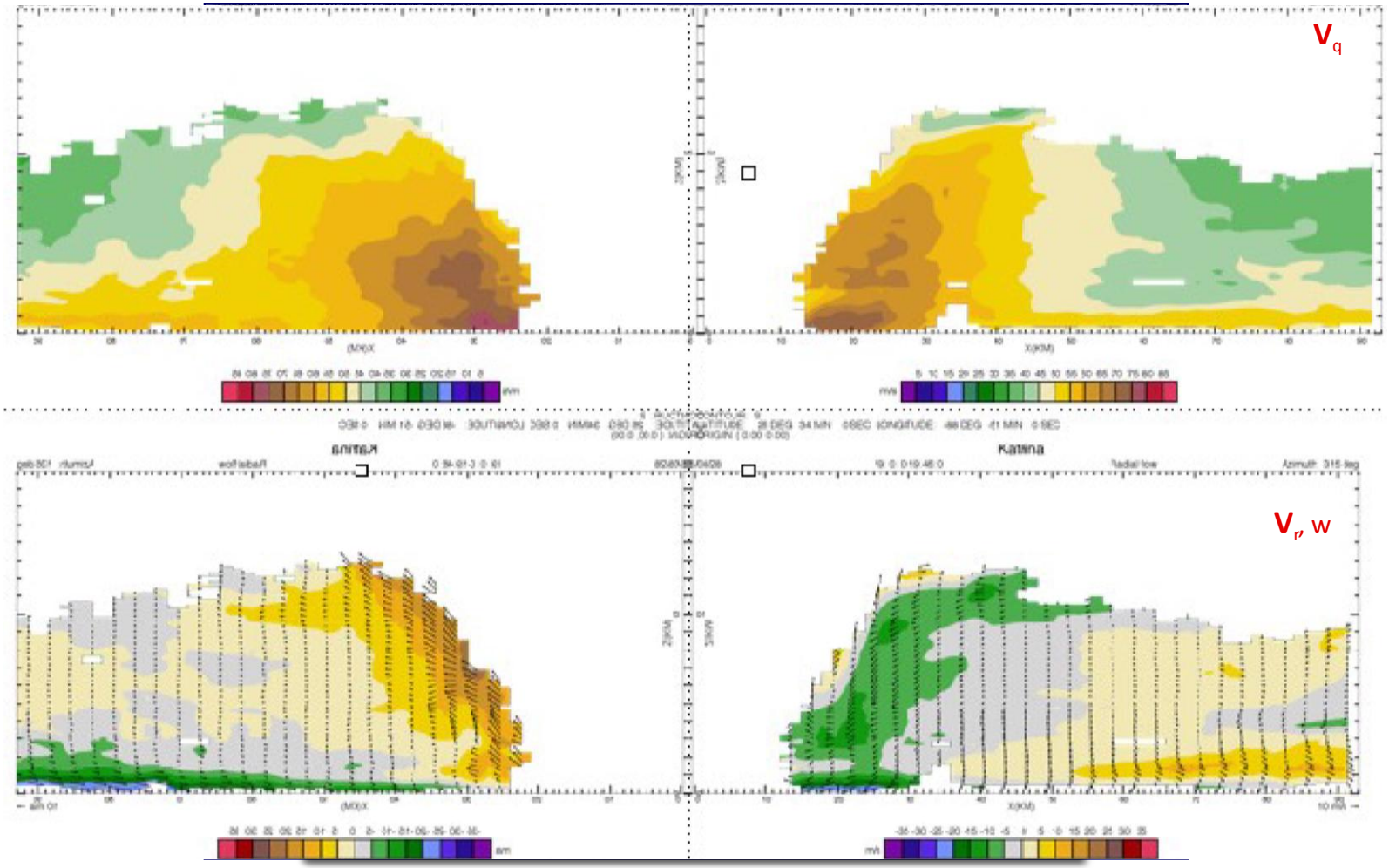




- Analytical & numerical studies.
- Ensemble track forecasting & targeted observations.

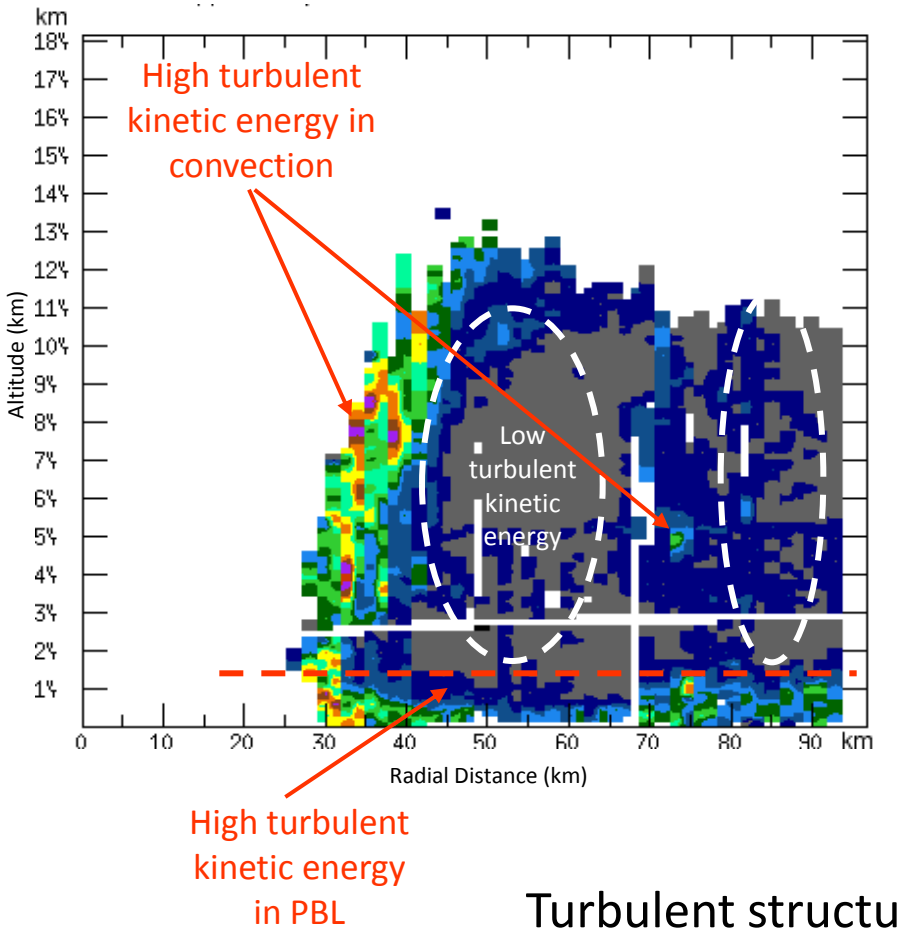
Improved Use of Observations:
Vortex-scale

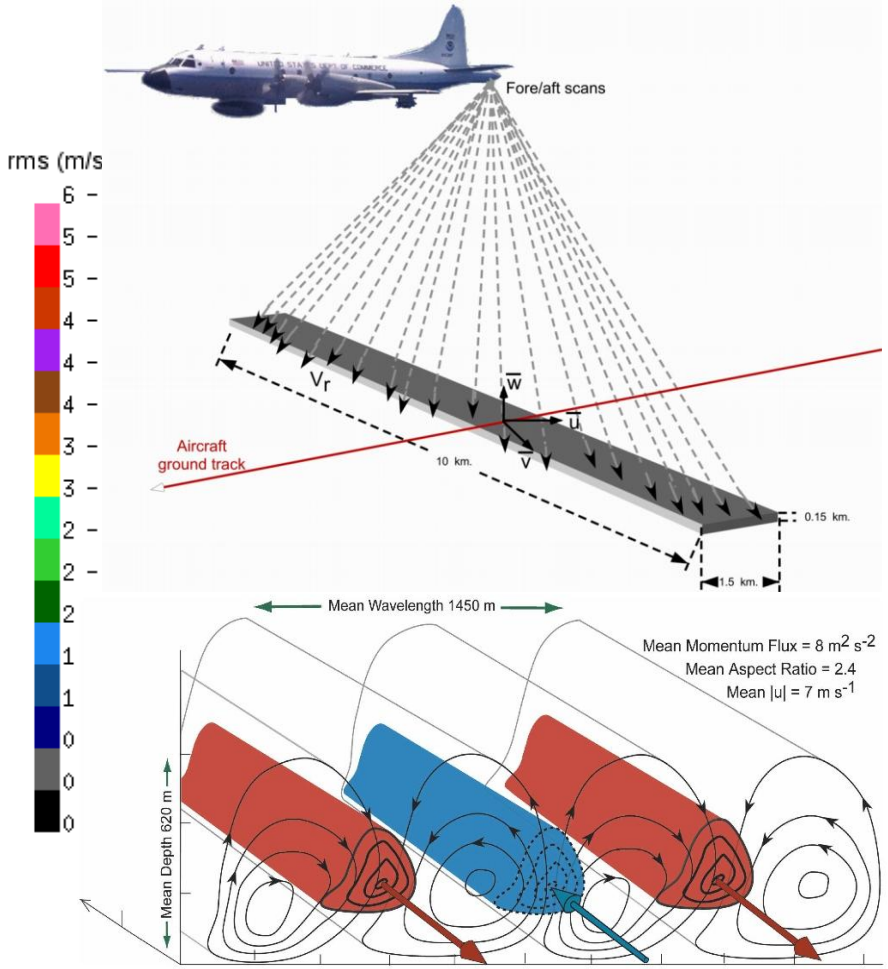
Airborne Doppler-analyzed wind field Hurricane Katrina, 28 September 2005



Improved Use of Observations:
Boundary Layer

Sub-grid Scale Turbulent Kinetic Energy



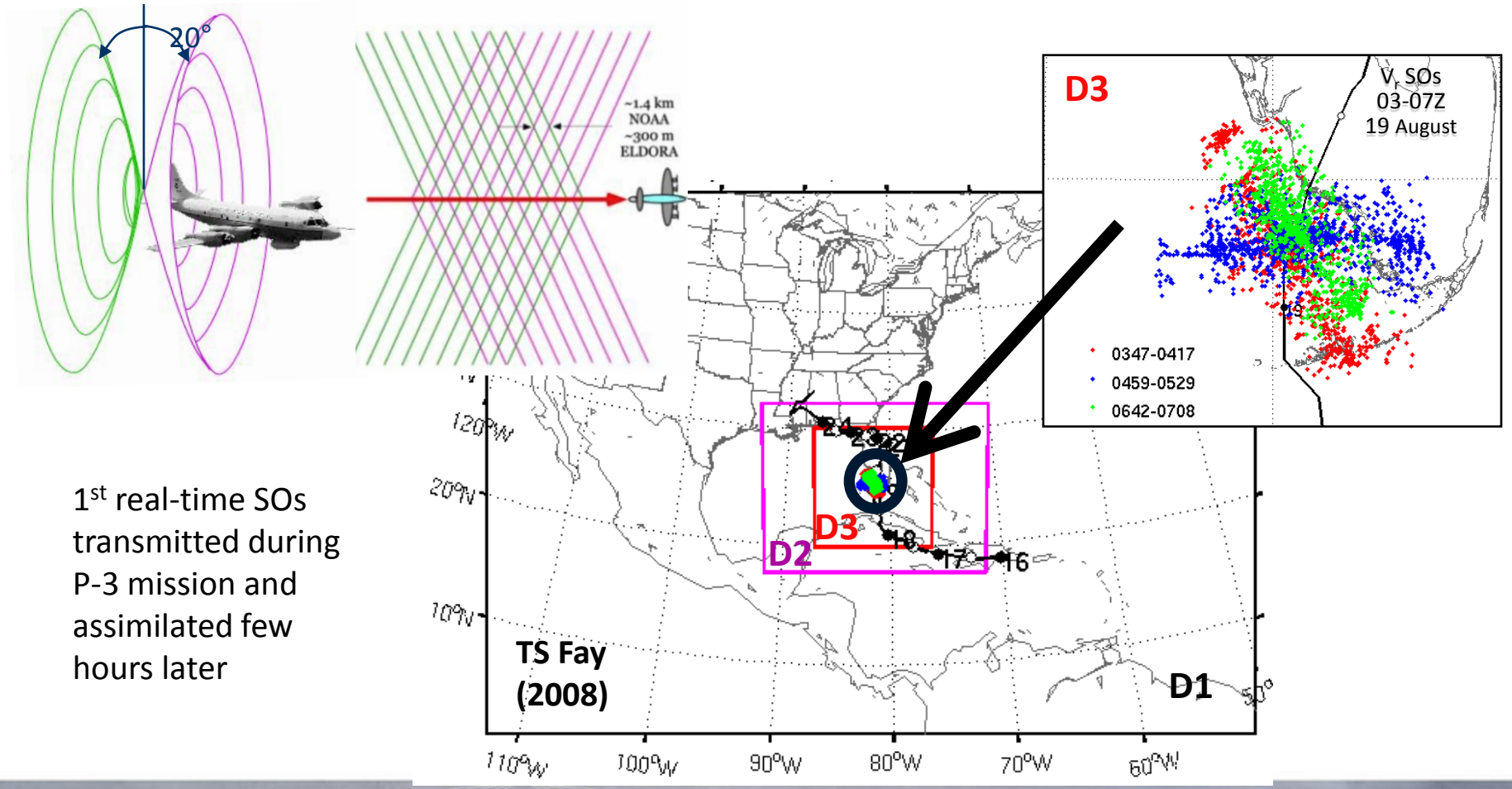


Turbulent structure / Boundary Layer Rolls

Improved Use of Observations:

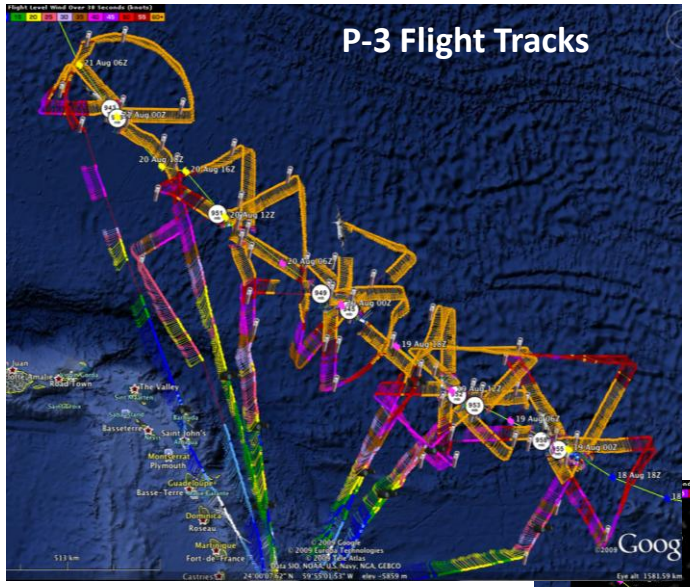
Assimilate Doppler Radar

EnKF data assimilation of inner core observations

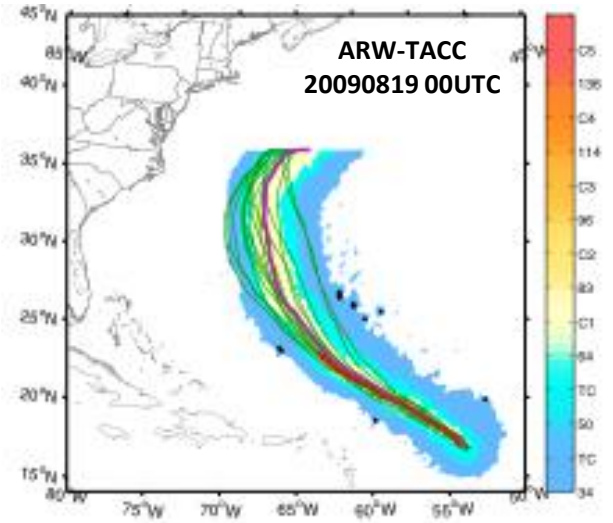


1st real-time SOs transmitted during P-3 mission and assimilated few hours later

Improved Use of Observations:
On-demand Test: Bill

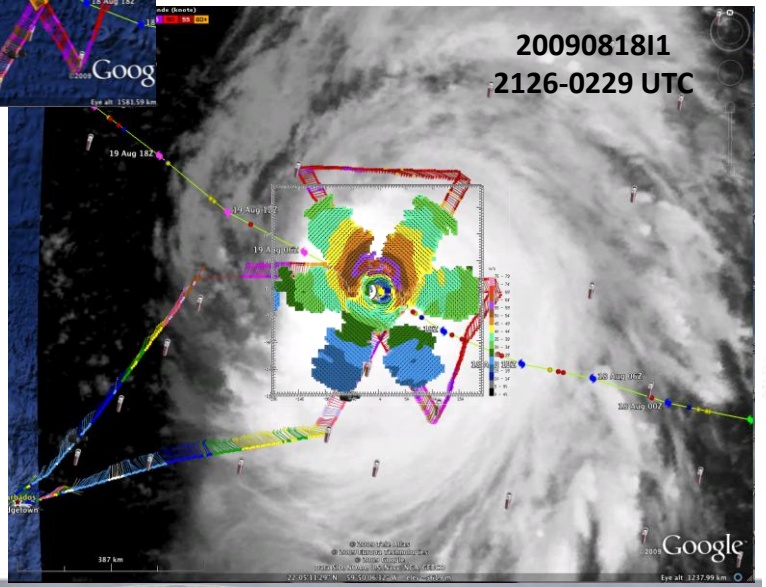


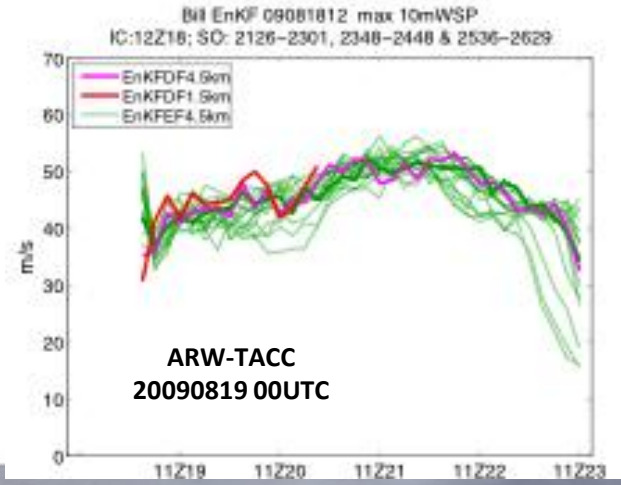
Doppler SO (EnKF) transmitted in real-time to TACC for assimilation into ARW model



(Courtesy of Fuqing Zhang)

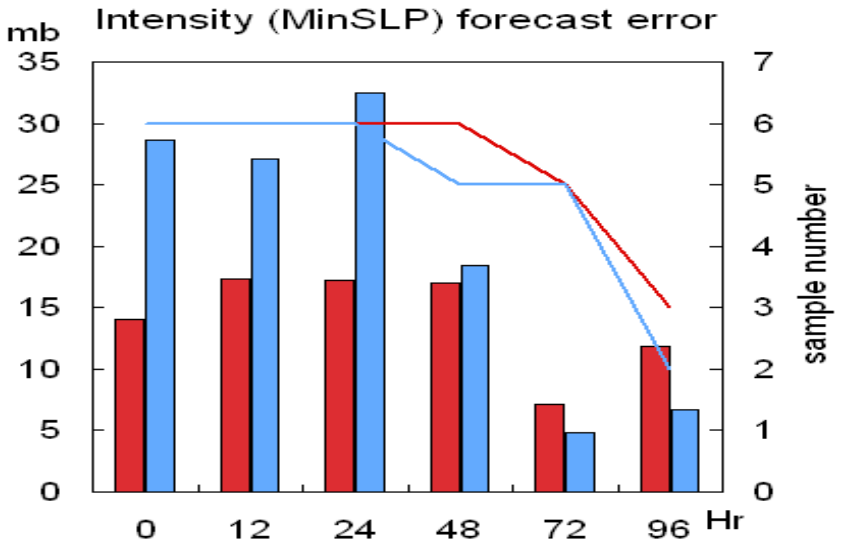
5 missions at 12-h intervals
00Z 19 – 00Z 21 August collecting Doppler SO (EnKF)

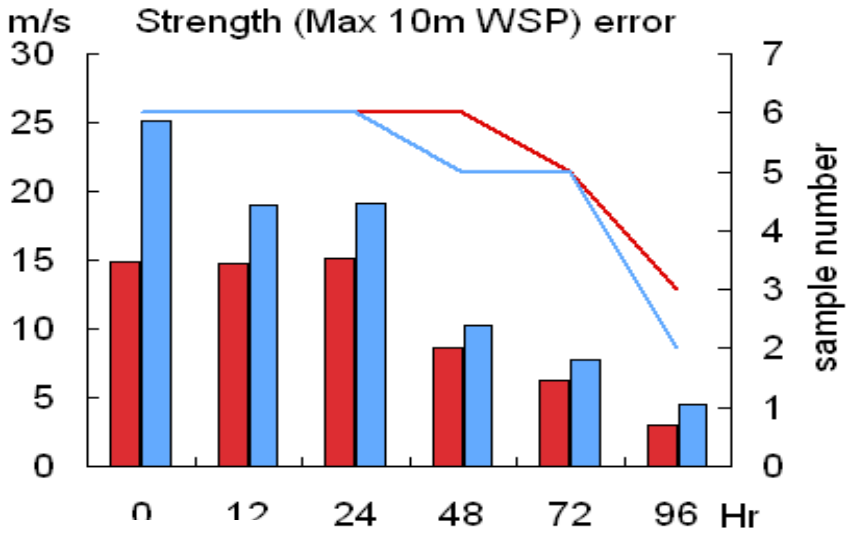


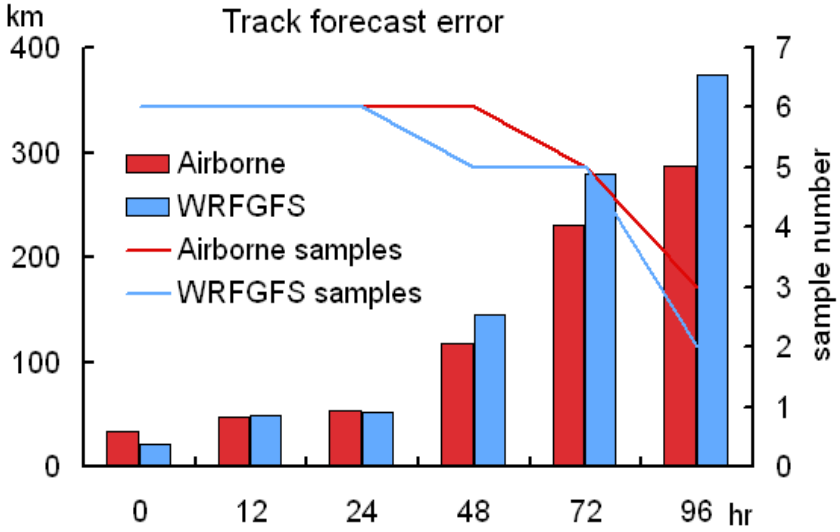


Eric Uhlhorn, Gamache (AOML/HRD), Fuqing Zhang (PSU)

Forecast error with airborne radar-derived radial velocities





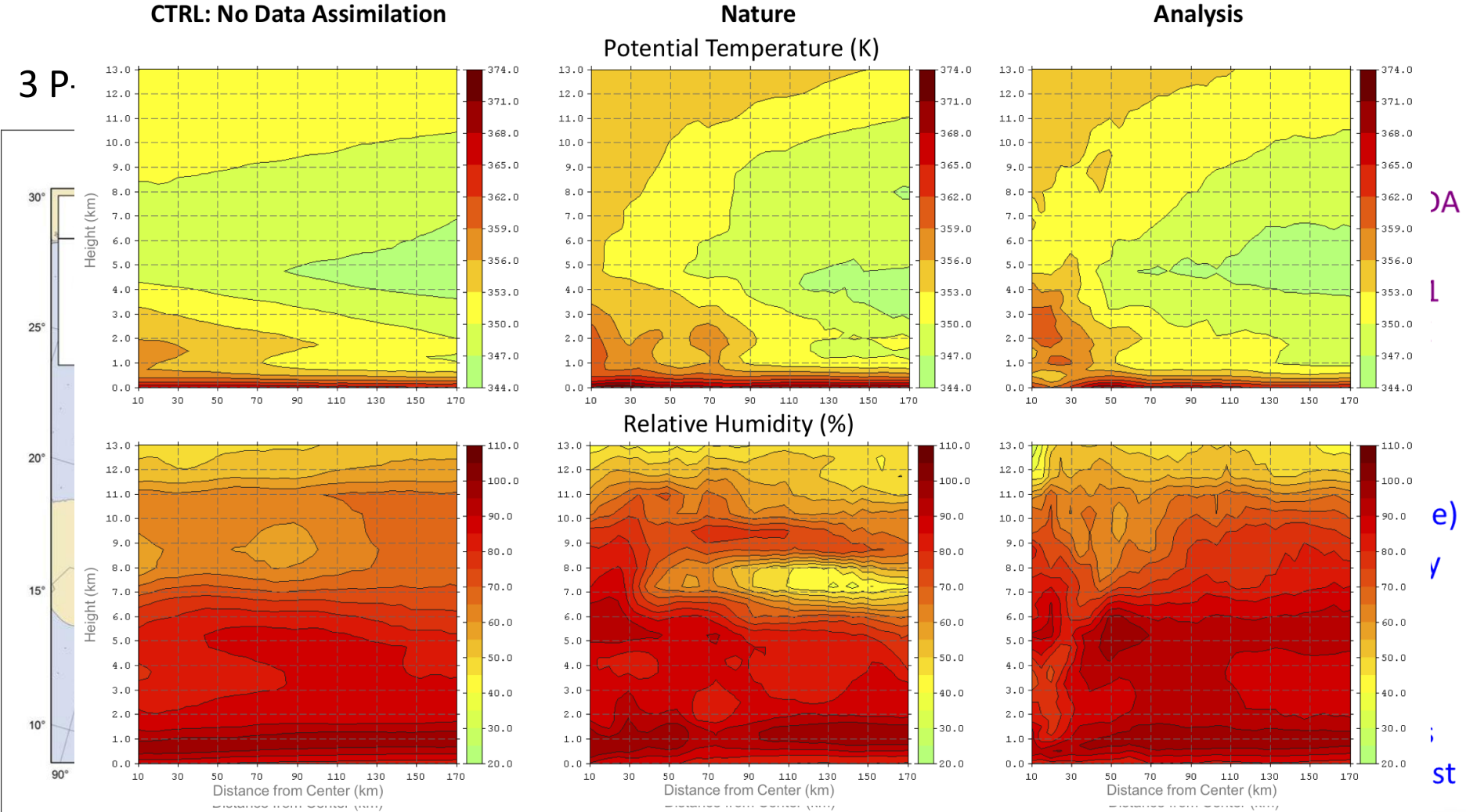


Note that sample size is very small but it does indicate a significant improvement in intensity out to 48 hours and track at 4 days

Yonghui Wen and Fuqing Zhang (PSU)

Improved Use of Observations:

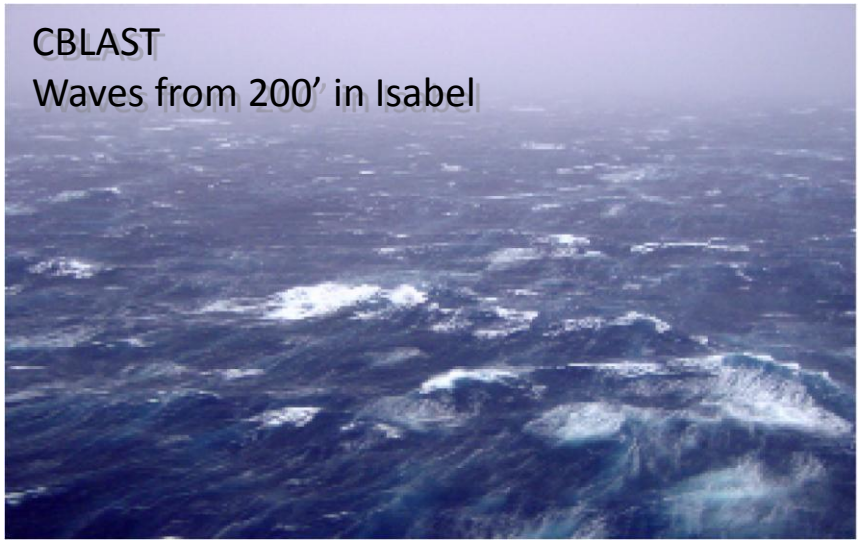
Assessing Doppler radar – OSSEs

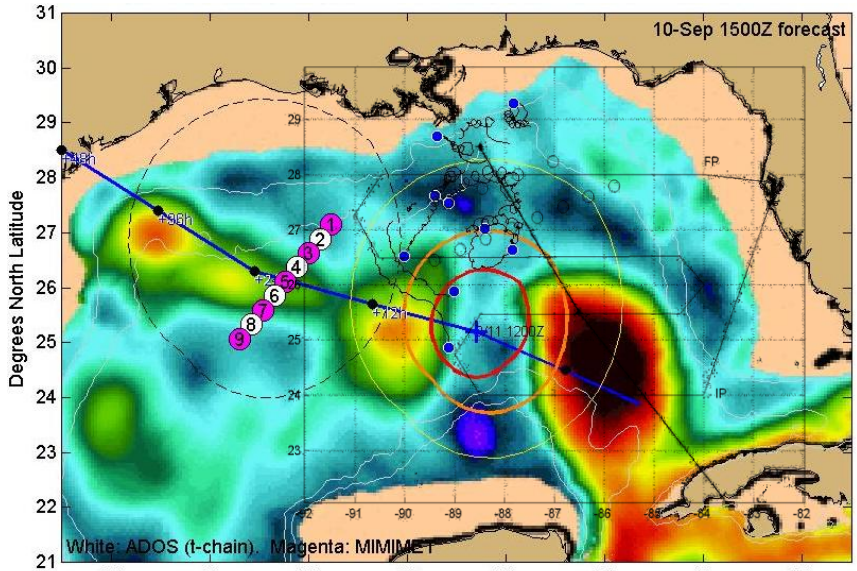


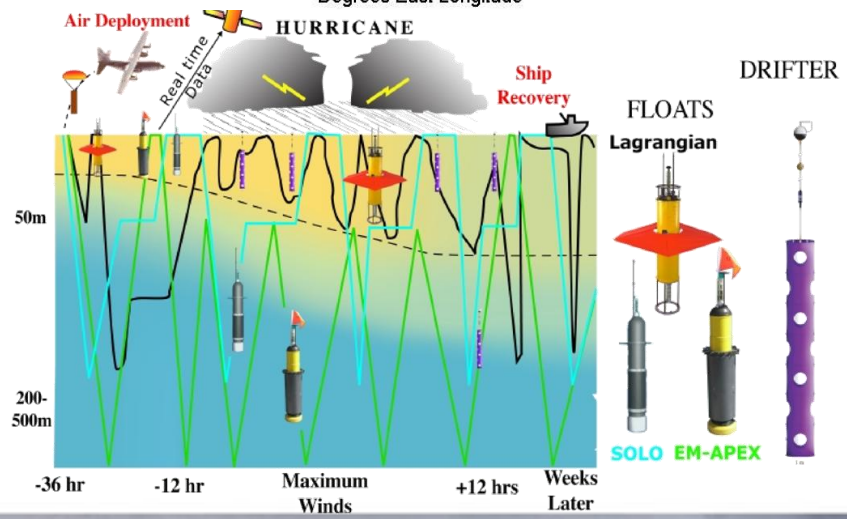
Improved Use of Observations:
Air-sea interaction

Targeted upper ocean observations

TC impact on upper ocean effect of Hurricanes Gustav and Ike (2008)



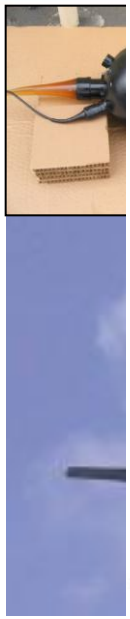


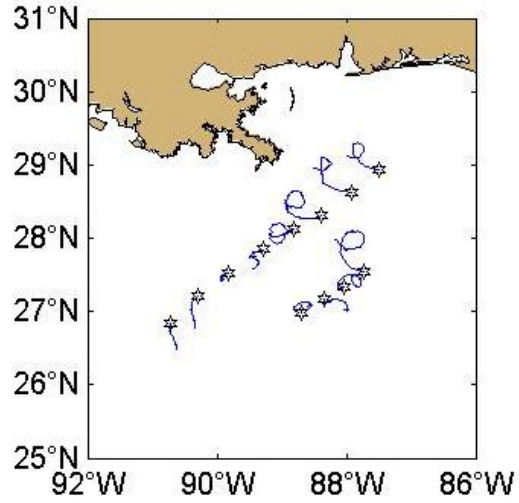


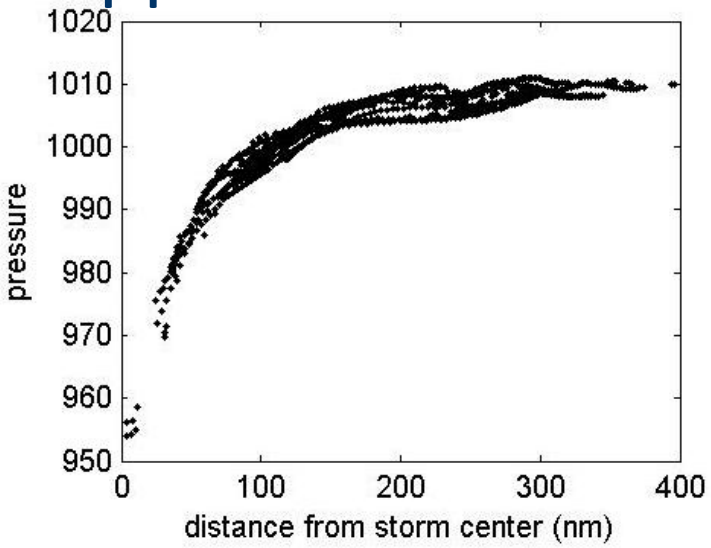
E. Uhlhorn, AOML/HRD, R. Lumpkin AOML/PhOD

Improved Use of Observations:

Upper Ocean Observations

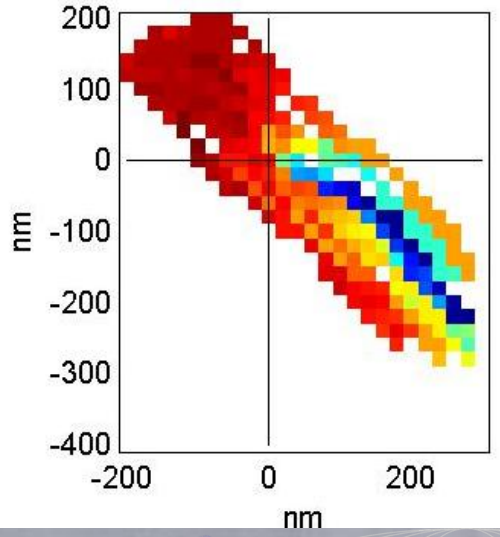




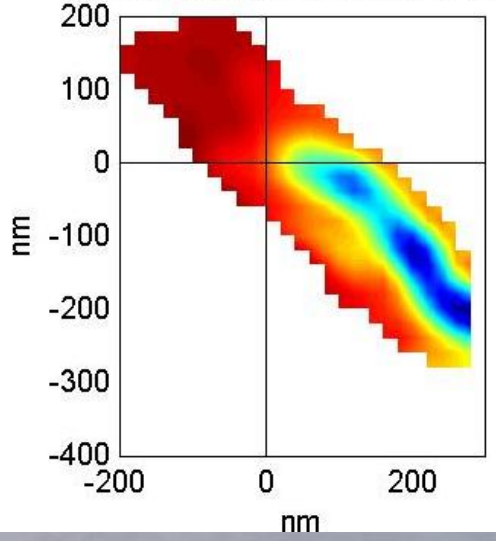


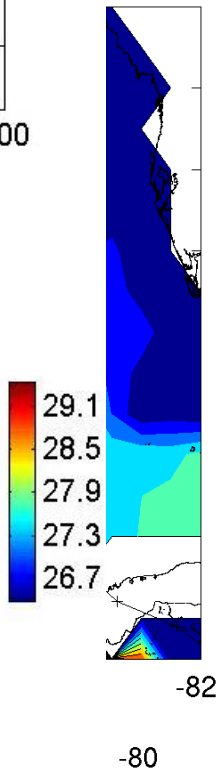
)8)

SST in Gustav-centered coordinates



Gustav's wake (OI smoothed)





E. Uhlhorn, AOML/HRD, R. Lumpkin AOML/PhOD

Improved Use of Observations:
Model evaluation

- Critical to HFIP success: Massive amounts of simulation output:
- High-res hurricane (HRH) test: 69 cases for 6-7 model teams - 50 Tb
- 2008 & 2009 HFIP Real-time test – >100 cases plus multi-model regional ensembles
- Tools needed to evaluate more than track and peak wind (e.g., large-scale, vortex-scale, convective scale, probability)

Milestones:

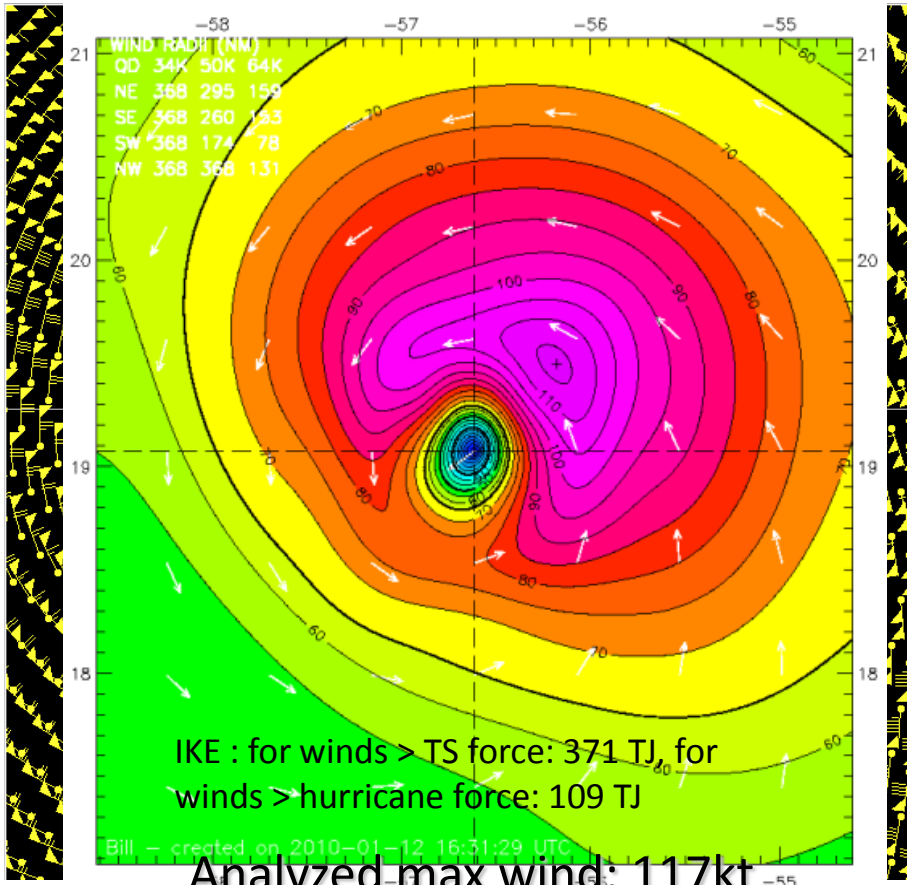
- ✓ Develop & test HWRF and FIM large-scale evaluation tools (track, DLM, shear, SHIPS & RI diagnostics)
- ✓ Develop & test HWRF vortex-scale evaluation tools (storm-centered diagnostics, e.g., R-Z mean, Hovmöller, wavenumber, wind radii, IKE)
- ✓ Develop & test convective-scale evaluation tools (CFADs, mass flux, latent heat distribution, microphysics, water mass, precipitation, reflectivity, satellite T_b)
- ✓ Hurricane Data Warehouse (observations, model simulations, etc.)

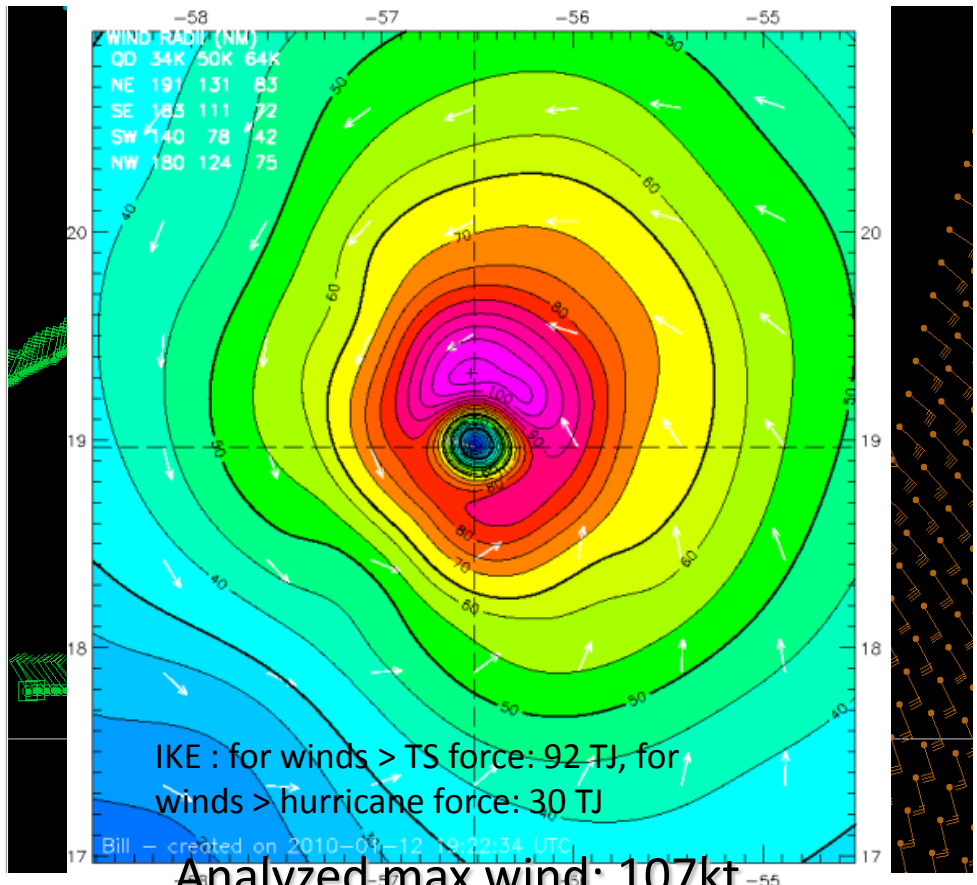
Improved Use of Observations:

HRH cases (Bill): Surface winds

Hurricane Bill Aug. 19, 2009 1600 UTC

HWRFx 10m winds **Data Coverage** **H*Wind 10m winds**





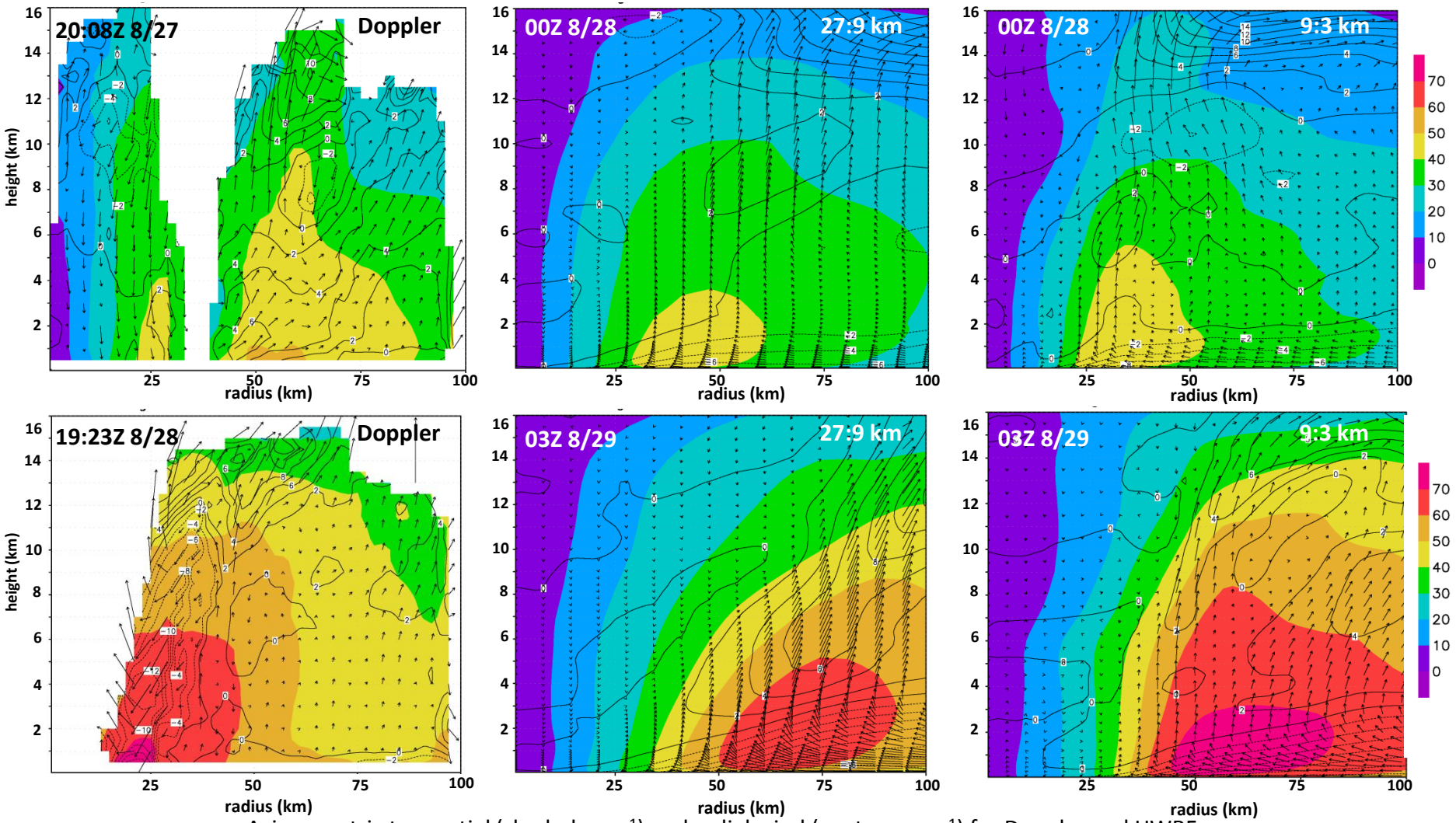
Analyzed max wind: 117kt from HWRFx, 37 nmi

Analyzed max wind: 107kt from Tail Doppler, 23 nmi

Improved Use of Observations:

HRH cases (Katrina): Vortex Structure

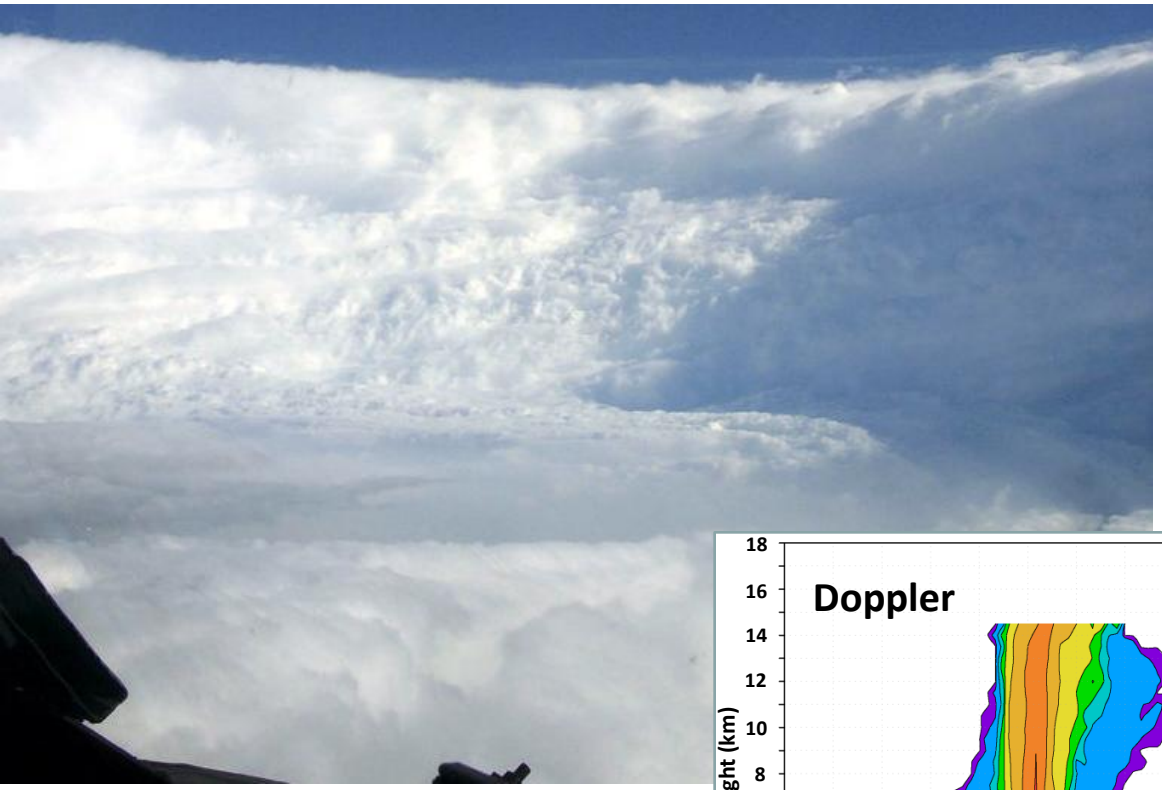
Hurricane Katrina simulation starting at 00Z 27 August 2008



Axisymmetric tangential (shaded, m s^{-1}) and radial wind (contour, m s^{-1}) for Doppler and HWRFx

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

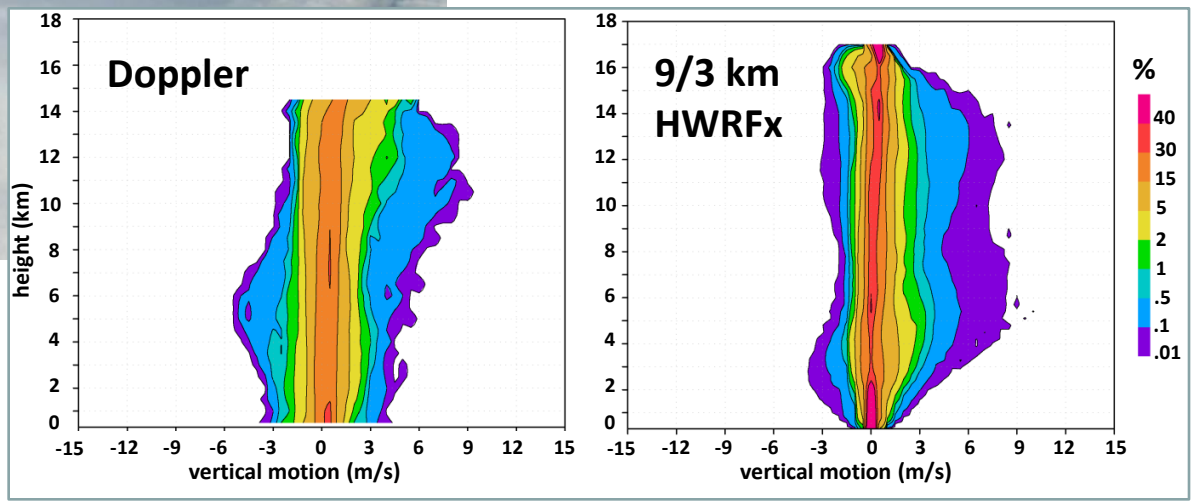
Improved Use of Observations:
Convective-scale



Eyewall of Hurricane Katrina 28 August 2005

Contoured frequency by altitude diagrams (CFADs) – Variation of PDF with height

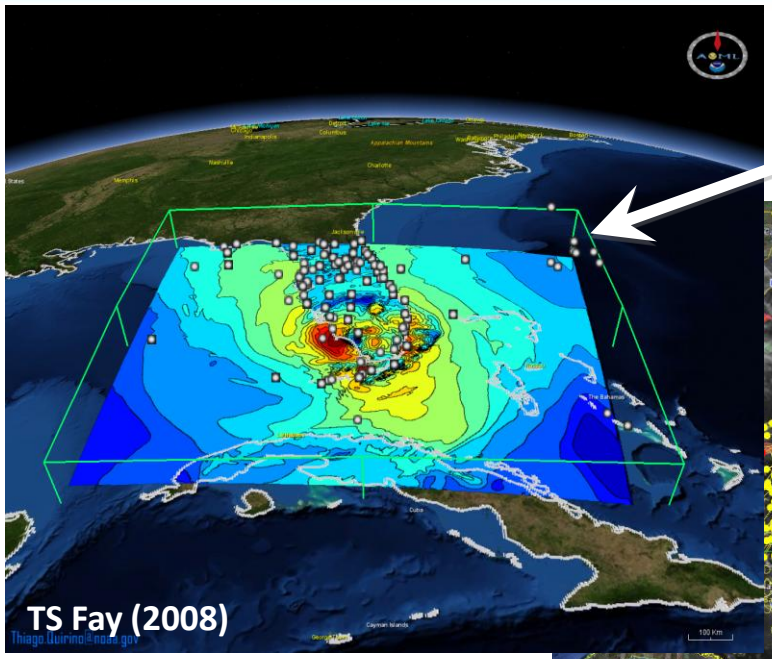
vertical motion



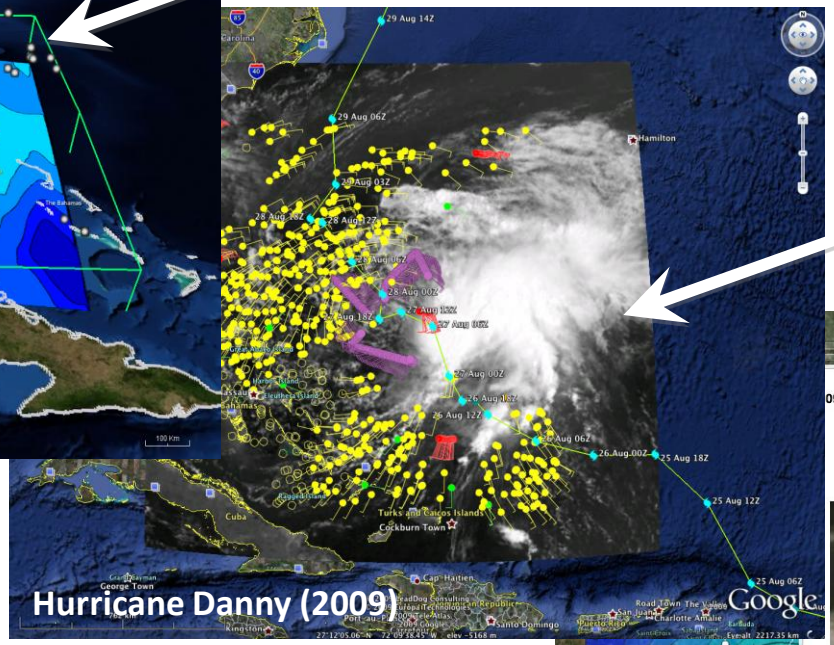
2038-2231 UTC 8/28 **0900 UTC 8/29**

Improved Use of Observations:

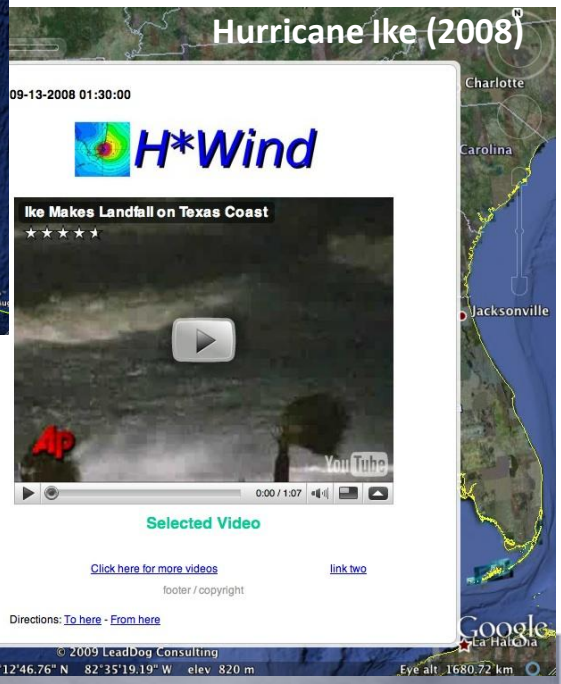
Visualization of Model and Observations



- Integration of HWind database & Model



- Integration of HWind database & NRL satellite imagery



- Exploring AWIPS-II integration through use of common standards

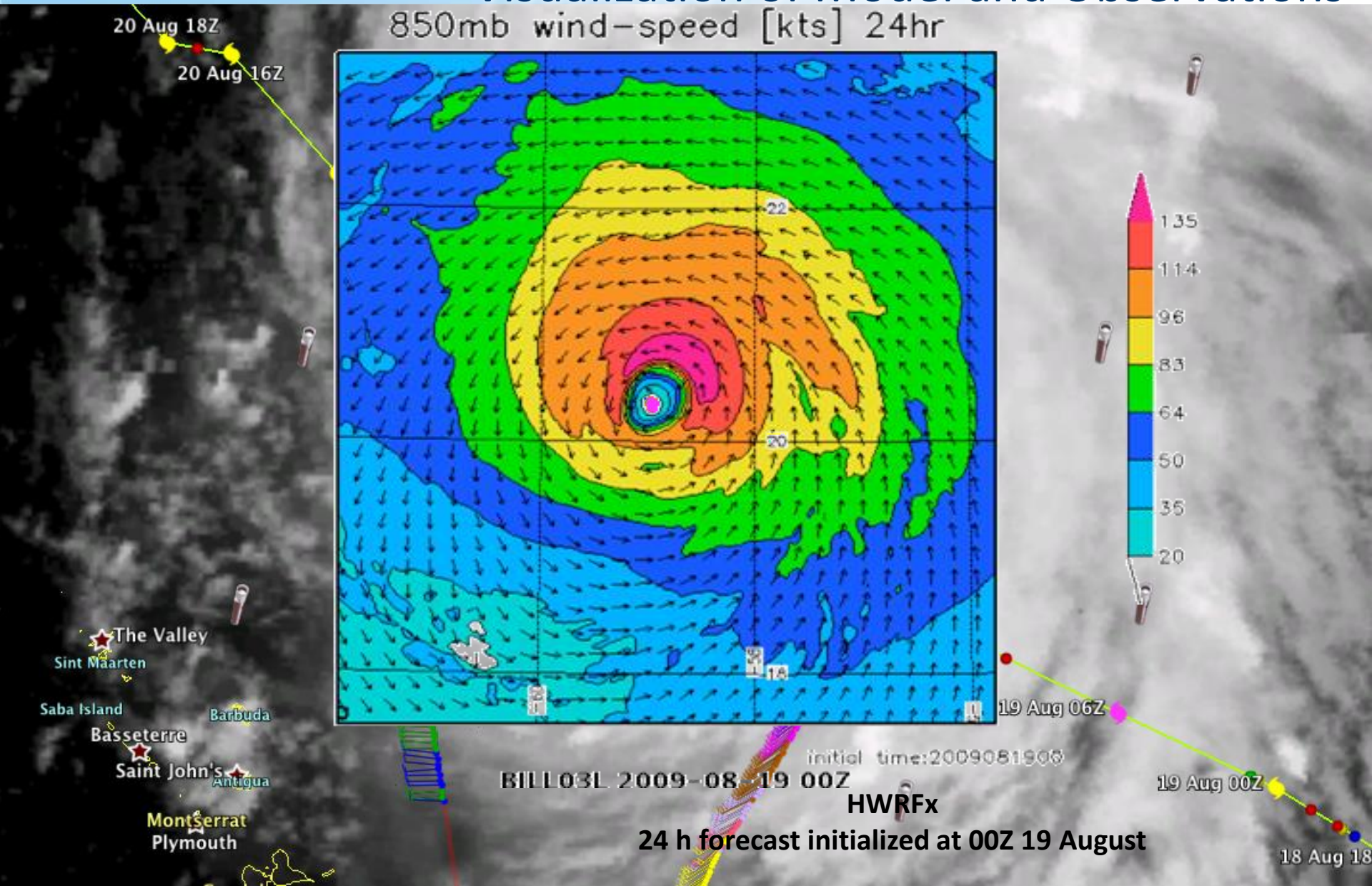
- Integration of HWind database & YouTube

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

Thiago Quirino, Guy Ravitz, AOML/HRD

Improved Use of Observations:

Visualization of Model and Observations



HWRFx

24 h forecast initialized at 00Z 19 August

Observations, Analysis, Instrument R&D – 2010

IFEX 2010

- 2 NOAA WP-3D, G-IV – 700 flight hour (1 June-30 November)
- N42RF will be available by early June, N43RF available early August, N49RF (G-IV) available early June
- Crews available 2/day missions starting July (Tampa and deployments)
- Base from Tampa, FL; St. Croix, USVI; & Barbados

NASA Genesis and Rapid Intensity Processes (GRIP)

- DC-8 and Global Hawk (GH) – 200 flight hour (15 August-30 September)
- Base Ft. Lauderdale, FL (DC-8); Edwards AFB (GH)

NSF Pre-Depression Investigation of Cloud-systems in the Tropics (PREDICT)

- G-V (HAIPER) – 200 flight hour (15 August-30 September)
- Base St. Croix, USVI

Summary

Keys to success:

- Partnership: AOML, ESRL, GFDL, DTC, USWRP, NESDIS/STAR working closely with Operations (EMC, NHC, AOC) and Federal & Academic Partners (NASA, NSF, ONR, NRL, NCAR, MMS)
- More integrated use & support of Testbeds: JHT, DTC, JCSDA
- Blend Traditional hurricane research activities and HFIP research activities
- Manpower (diversity) to evaluate model performance with hurricane data sets is a critical need