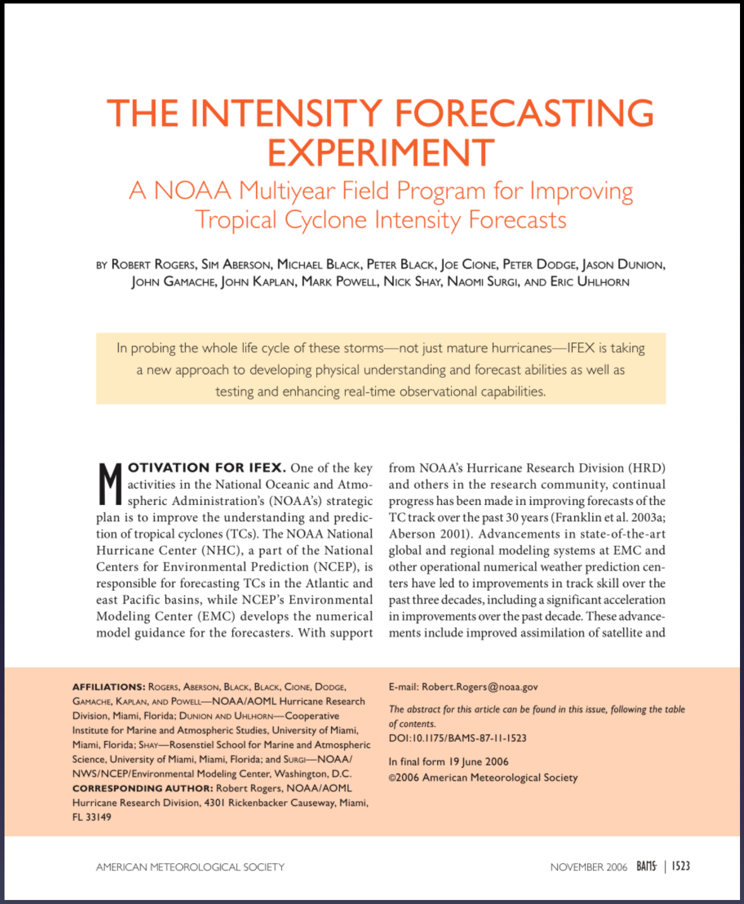
Intensity Forecasting Experiment (IFEX)
2012 Hurricane Field Campaign

Paul Reasor – Assistant HFP Director
Hurricane Research Division

September 5, 2012

Intensity Forecasting Experiment (IFEX; Rogers et al., BAMS, 2006)



THE INTENSITY FORECASTING EXPERIMENT

A NOAA Multiyear Field Program for Improving Tropical Cyclone Intensity Forecasts

BY ROBERT ROGERS, SIM ABERSON, MICHAEL BLACK, PETER BLACK, JOE CIONE, PETER DODGE, JASON DUNION, JOHN GAMACHE, JOHN KAPLAN, MARK POWELL, NICK SHAY, NAOMI SURGI, AND ERIC UHLHORN

In probing the whole life cycle of these storms—not just mature hurricanes—IFEX is taking a new approach to developing physical understanding and forecast abilities as well as testing and enhancing real-time observational capabilities.

MOTIVATION FOR IFEX. One of the key activities in the National Oceanic and Atmospheric Administration's (NOAA's) strategic plan is to improve the understanding and prediction of tropical cyclones (TCs). The NOAA National Hurricane Center (NHC), a part of the National Centers for Environmental Prediction (NCEP), is responsible for forecasting TCs in the Atlantic and east Pacific basins, while NCEP's Environmental Modeling Center (EMC) develops the numerical model guidance for the forecasters. With support from NOAA's Hurricane Research Division (HRD) and others in the research community, continual progress has been made in improving forecasts of the TC track over the past 30 years (Franklin et al. 2003a; Aberson 2001). Advancements in state-of-the-art global and regional modeling systems at EMC and other operational numerical weather prediction centers have led to improvements in track skill over the past three decades, including a significant acceleration in improvements over the past decade. These advancements include improved assimilation of satellite and

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The abstract for this article can be found in this issue, following the table of contents.
DOI:10.1175/BAMS-87-11-1523
In final form 19 June 2006

IFEX intended to improve prediction of TC intensity change by:

1) collecting observations that span TC life cycle in a variety of environments for model initialization and evaluation
2) developing and refining measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment
3) improving understanding of physical processes important in intensity change for a TC at all stages of its life cycle

These goals provide the linkage between observations, modeling, and theory that form the foundation of the Hurricane Forecast Improvement Project (HFIP)

Percentage (%) of on-station aircraft flight hours

	Pre- IFEX 1956-2004	IFEX 2005-2011
Pre-TD	**4.3**	**9.9**
TD	**7.2**	**5.5**
TS	**26.8**	**37.1**
Cat 1-2	**31.6**	**24.8**
Cat 3-5	**30.0**	**22.7**

Pre-IFEX: 8020 total hours flown
IFEX: 2526 total hours flown

Notable storms (2006-2011) flown by NOAA aircraft

Storm	Dates of NOAA missions	NOAA Aircraft	Dropsondes	Operational Radar analyses	Comments
TS Debby	Aug 24-26 2006	N49 (2)	59	0	SAL
TS Helene	Sept 14-20 2006	N42 (4), N49 (4)	209	2	SAL
Hurr Felix	Aug 31 - Sept 3 2007	N42 (2), N43 (2)	46	5	RI, major hurricane
TS Ingrid	Sept 12-18 2007	N42 (3), N43 (3)	66	13	Sheared system
TS Karen	Sept 25-28 2007	N42 (1), N43 (1)	5	7	Sheared system
TS Fay	Aug 14-19 2008	N42 (3), N43 (3), N49 (4)	212	19	Genesis, landfall
Hurr Gustav	Aug 28 - Sept 3 2008	N42 (3), N43 (4), N49 (4)	253	18	Lifecycle; first realtime transmission of superobs
Ike	Sept 5-15 2008	N42 (6), N43 (3), N49 (8)	419	16	Lifecycle; first realtime use of superobs in DA
Hurr Kyle	Sept 23-27 2008	N42 (4), N43 (4)	59	22	Genesis
Hurr Paloma	Nov 7-8 2008	N43 (3), N49 (2)	99	13	RI
Hurr Bill	Aug 18-21 2009	N43 (5), N49 (6)	288	13	Lifecycle; SAL
TD #2	July 6-8 2010	N42 (3), N49 (2)	121	19	Genesis
Earl	Aug 28 - Sept 3 2010	N42 (5), N43 (6), N49 (4)	393	35	RI and mature phase; with NASA GRIP DC-8 and Global Hawk
Hurr Karl	Sept 12-16 2010	N42 (2), N43 (2), N49 (4)	175	11	Genesis, RI; with NASA GRIP DC-8 and Global Hawk and NSF PREDICT G-V
Hurr Tomas	Nov 3-6 2010	N42 (3), N43 (2), N49 (1)	81	17	Sheared system
Irene	Aug 22-27 2011	N42 (4), N43 (3), N49 (9)	494	25	Lifecycle monitoring
Hurr Rina	Oct 25-27 2011	N42 (4), N49 (2)	129	8	Sheared system

Hurricane Irene P3 coverage (Aug. 23-27, 2011)

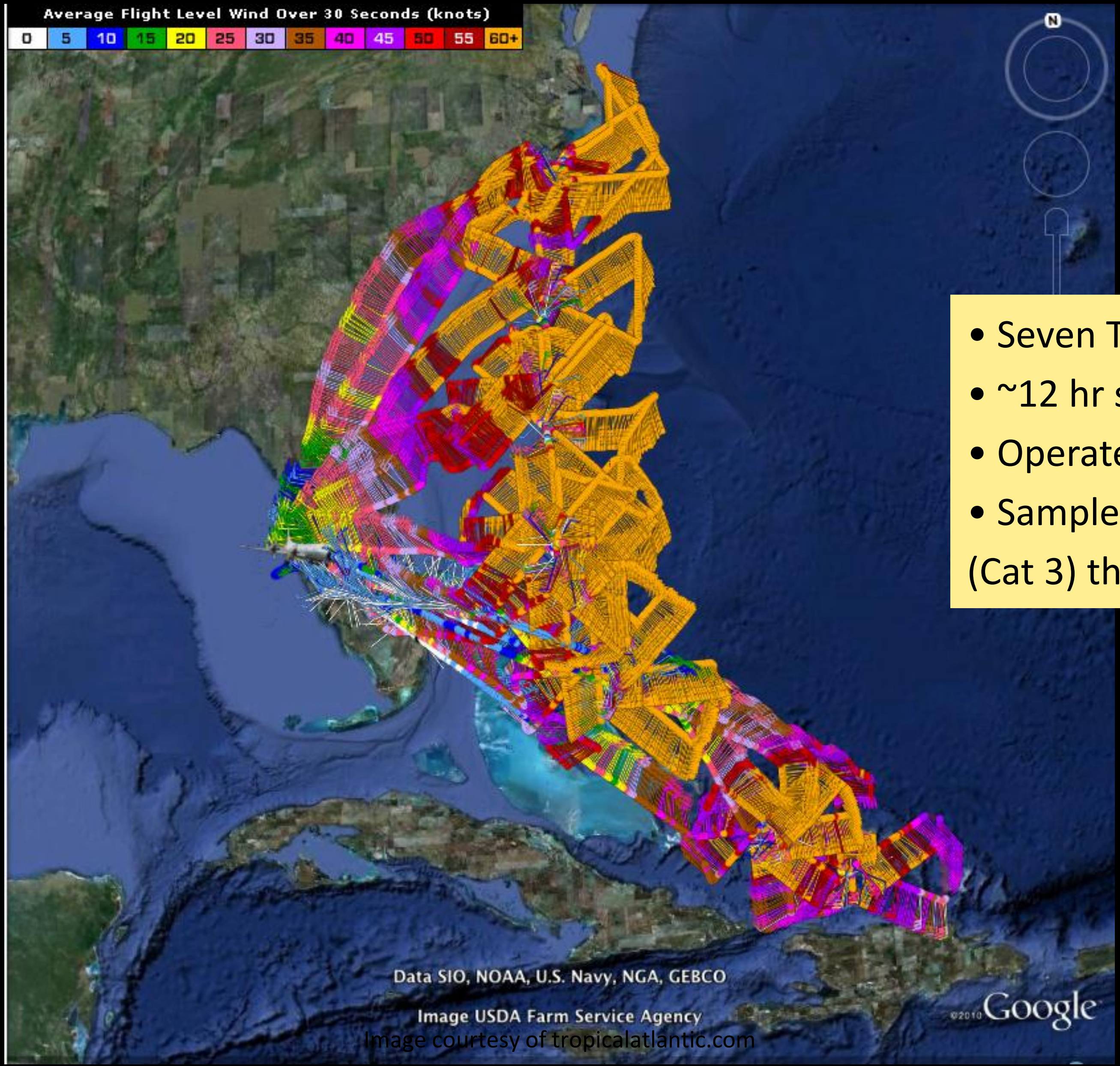
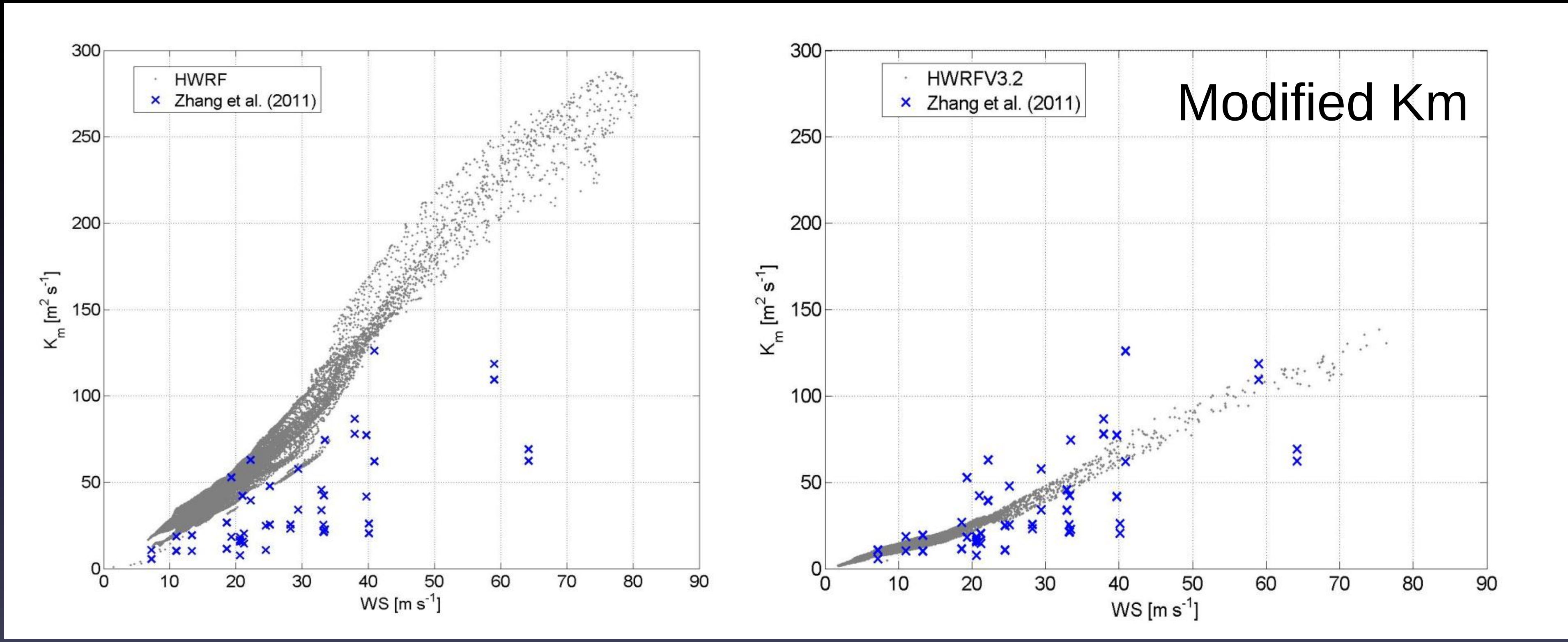


Image courtesy of tropicalatlantic.com

- Seven TDR flights (1 aborted)
- ~12 hr sampling cycle
- Operated out of MacDill AFB
- Sampled Irene as a major hurricane (Cat 3) through landfall (Cat 1)

IFEX Goal 1: Model evaluation

Modification of vertical eddy diffusivity (Km) in the operational HWRF model based on in situ measurements



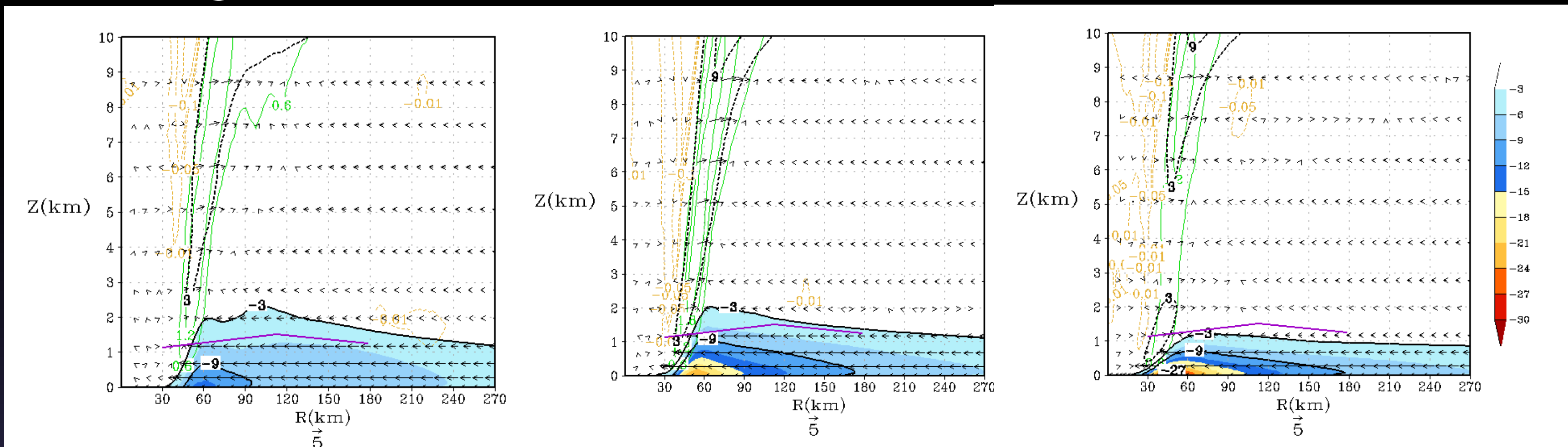
MRF-type PBL schemes are too diffusive

IFEX Goal 1: Model evaluation

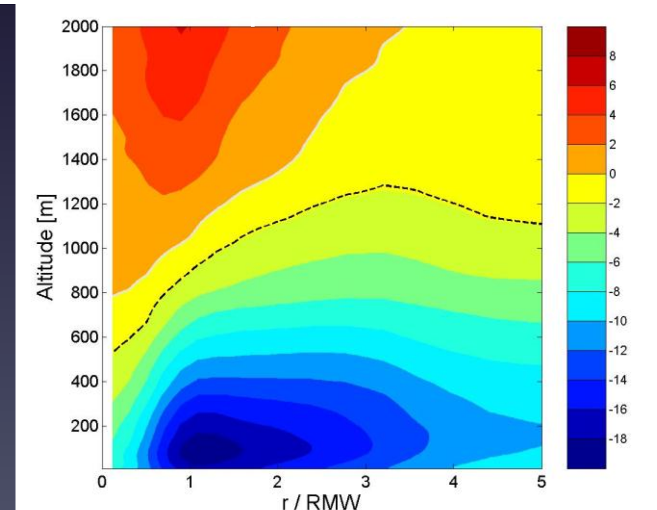
Sensitivity of axisymmetric radial wind to vertical eddy diffusivity

(Gopalakrishnan et al. 2012 JAS, in review)

Original Km in HWRF | Km reduced 50% | Km reduced 75%



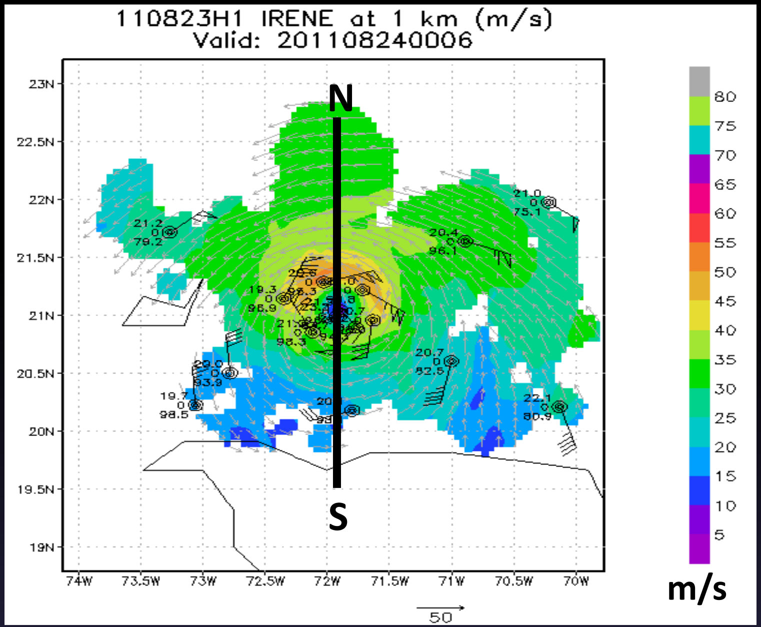
- peak radial inflow stronger with more accurate Km
- depth of inflow layer more consistent with dropsonde composites using more accurate Km

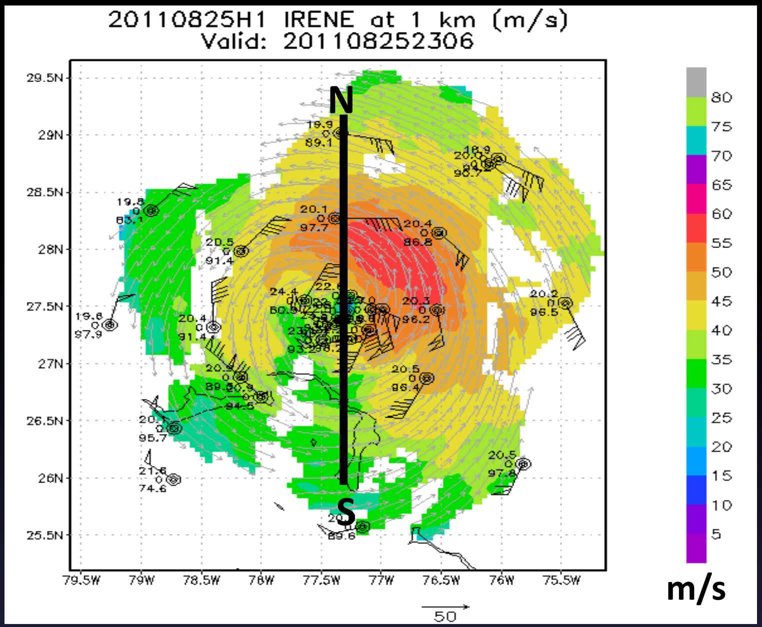


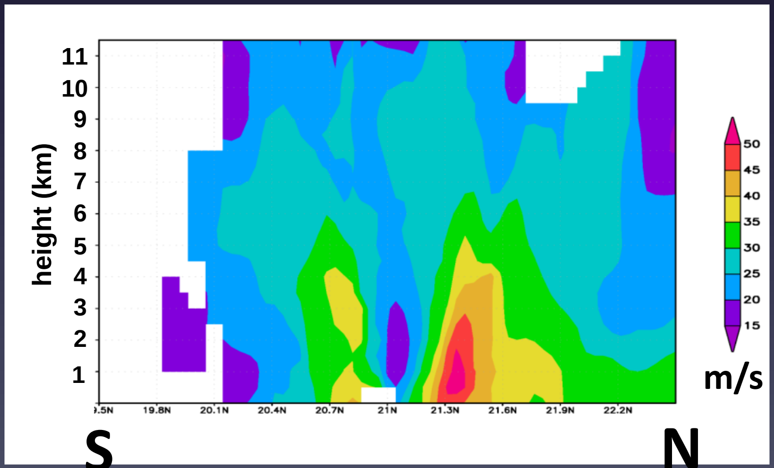
Dashed line is inflow layer depth from dropsonde composite (Zhang et al. 2011 MWR: On the characteristic height scales of the hurricane boundary layer).

IFEX Goal 2: Real-time monitoring of TC structure and intensity

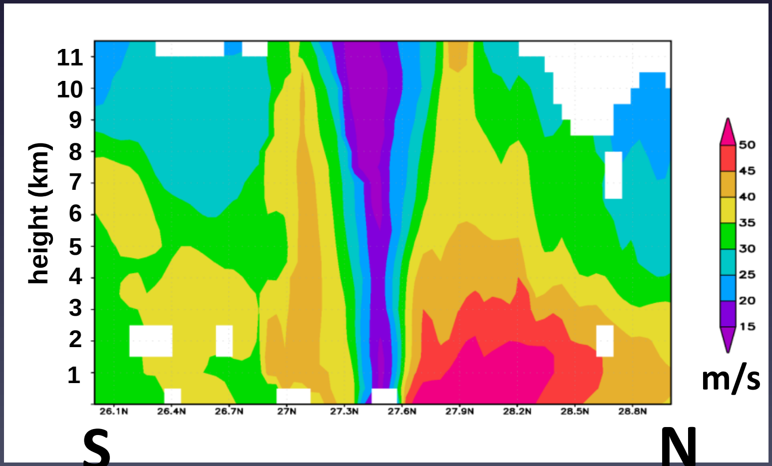
P-3 Tail Doppler and Dropsonde Measurements in Hurricane Irene (2011)







Flight 110823H1



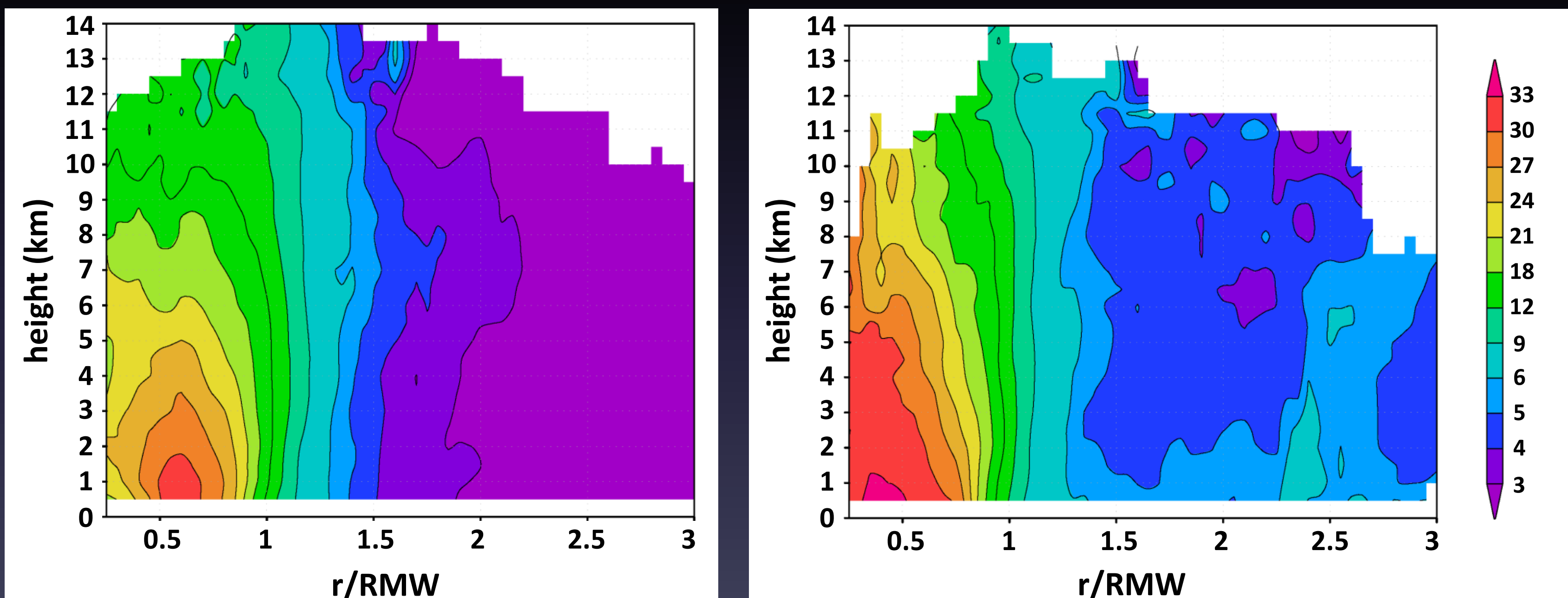
Flight 110825H1

IFEX Goal 3: Improved understanding of intensity change processes

TC inner-core structure and rapid intensification

Composite mean vertical vorticity (x 10^{-4} s^{-1})

Intensifiers | Steady state

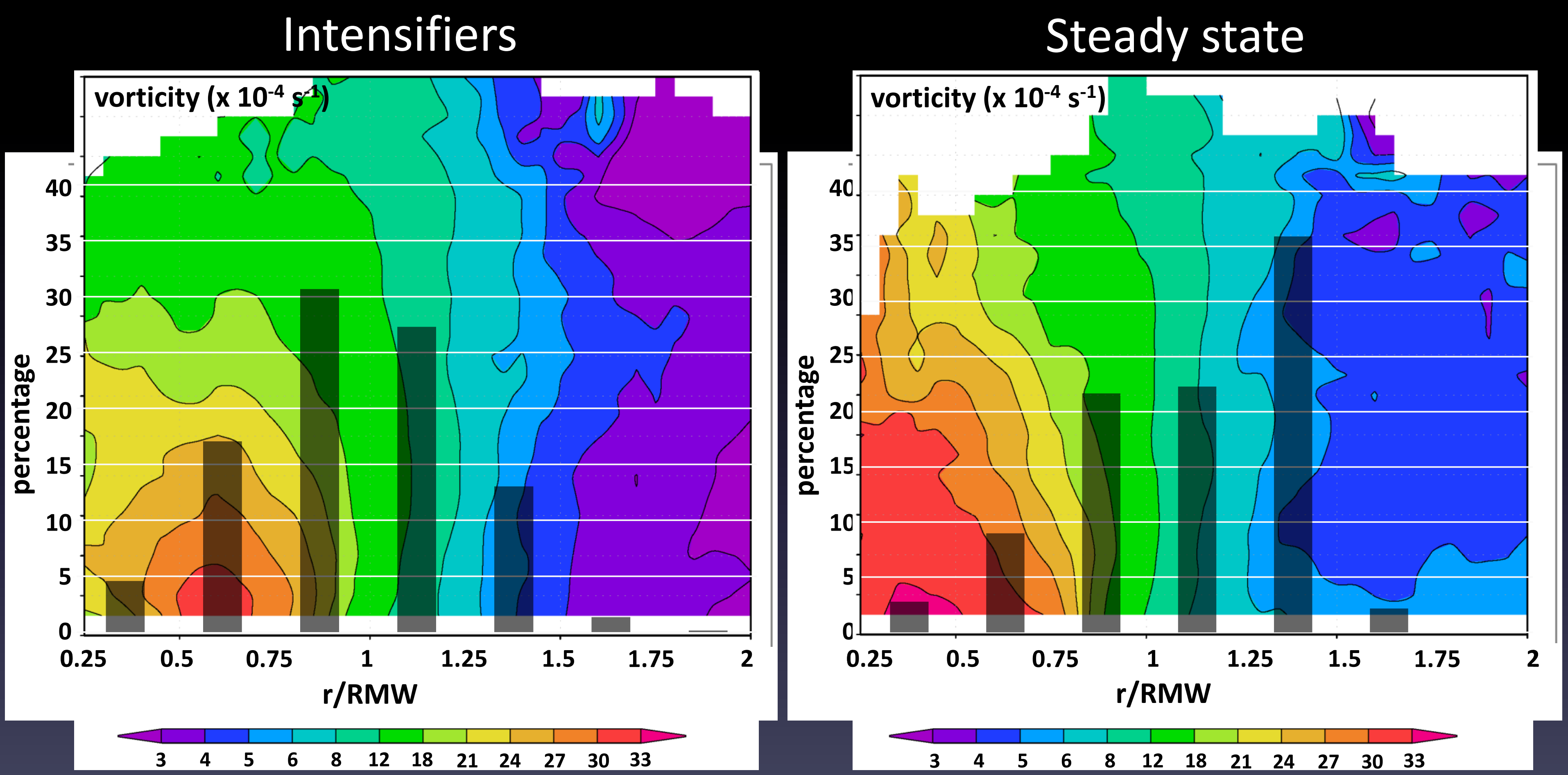


- more ring-like structure in eyewall vorticity, lower outer-core vorticity for RI cases

IFEX Goal 3: Improved understanding of intensity change processes

TC inner-core structure and rapid intensification

Radial distribution of convective bursts



RI cases show

- radial distribution of convective bursts that peaks inside RMW compared with outside RMW for SS cases

Focus areas for 2012

IFEX goal 1: Collecting observations for model initialization/evaluation

- P-3 3-D Doppler Winds Experiment (Tail Doppler Radar) TDR

IFEX goal 2: Developing and refining measurement technologies

- NESDIS Ocean Winds and Rain Experiment (P. Chang)
- UAS GALE Module (Cione)
- TC-Ocean Interaction Experiment (N. Shay, Uhlhorn)
- G-IV TDR Experiment (Gamache, Dodge, Reasor, Lorsolo, Aksoy)

IFEX goal 3: Improving understanding

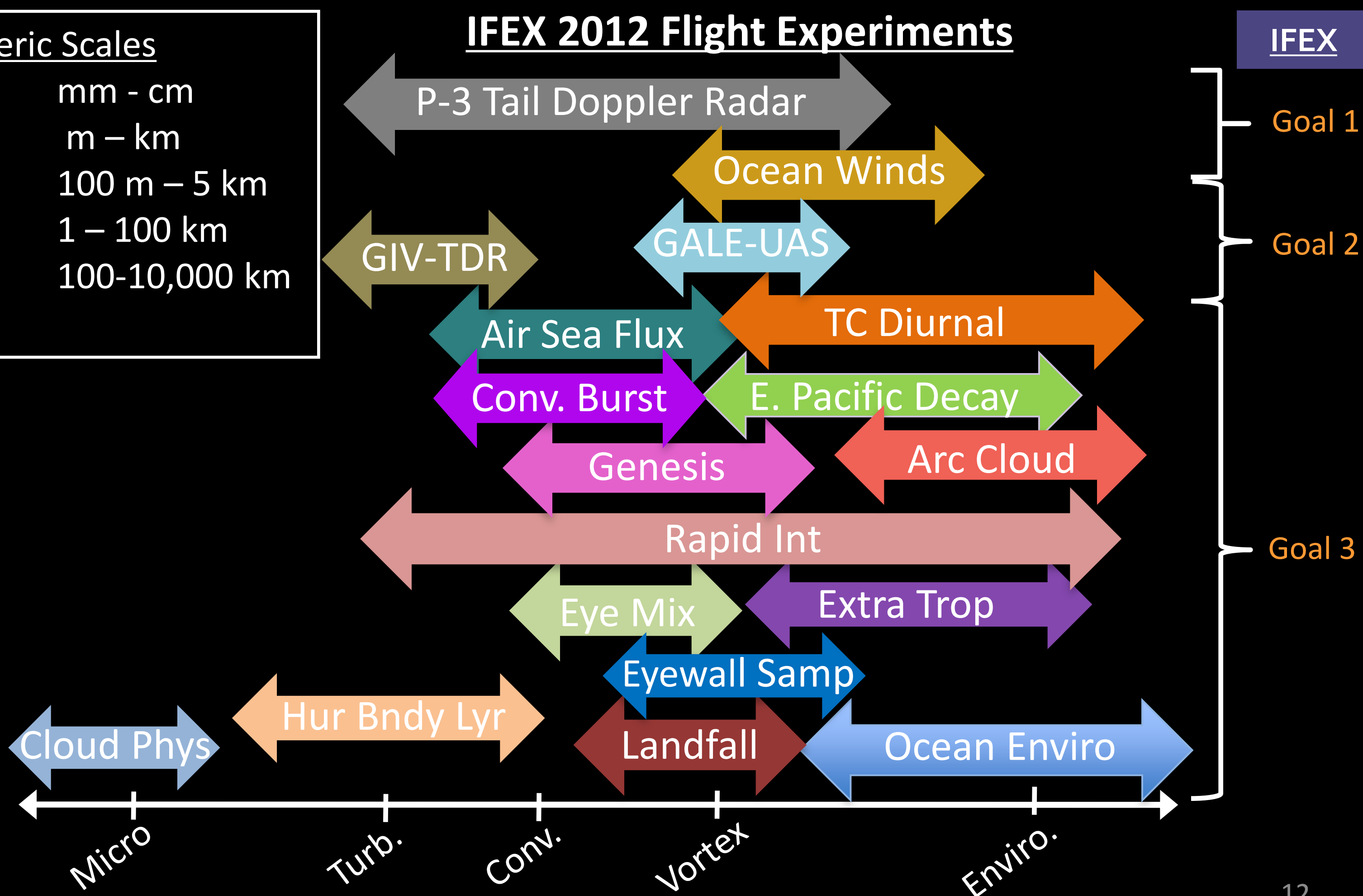
- E. Pacific Decay Experiment (E. Rappaport, Uhlhorn)
- TC Diurnal Cycle Experiment (Dunion)
- Extra-tropical Transition Experiment (Aberson)
- Genesis Experiment (Rogers, Reasor, Hogsett)
- -convective burst module
- Rapid Intensity Change Experiment (Kaplan, Rogers, Dunion)
- TC/AEW Arc Cloud Module (Dunion)
- Landfall and Inland Decay Experiment (Dodge, Kaplan)
- TC Eye Mixing Module (Aberson)
- Boundary Layer Inflow Module (Uhlhorn, J. Zhang)
- Eyewall Sampling and Intensity Change Module (J. Zhang and G. Barnes)
- Air-Sea Surface Flux Module (M. Bell, M. Montgomery, R. Rogers)
- Hurricane PBL Entrainment Flux Module (J. Zhang. G. Barnes)
- Aerosol/Cloud Droplet Measurement module (R. Black)

Intensity change is a multi-scale process

- Sample TCs and the environment on all scales

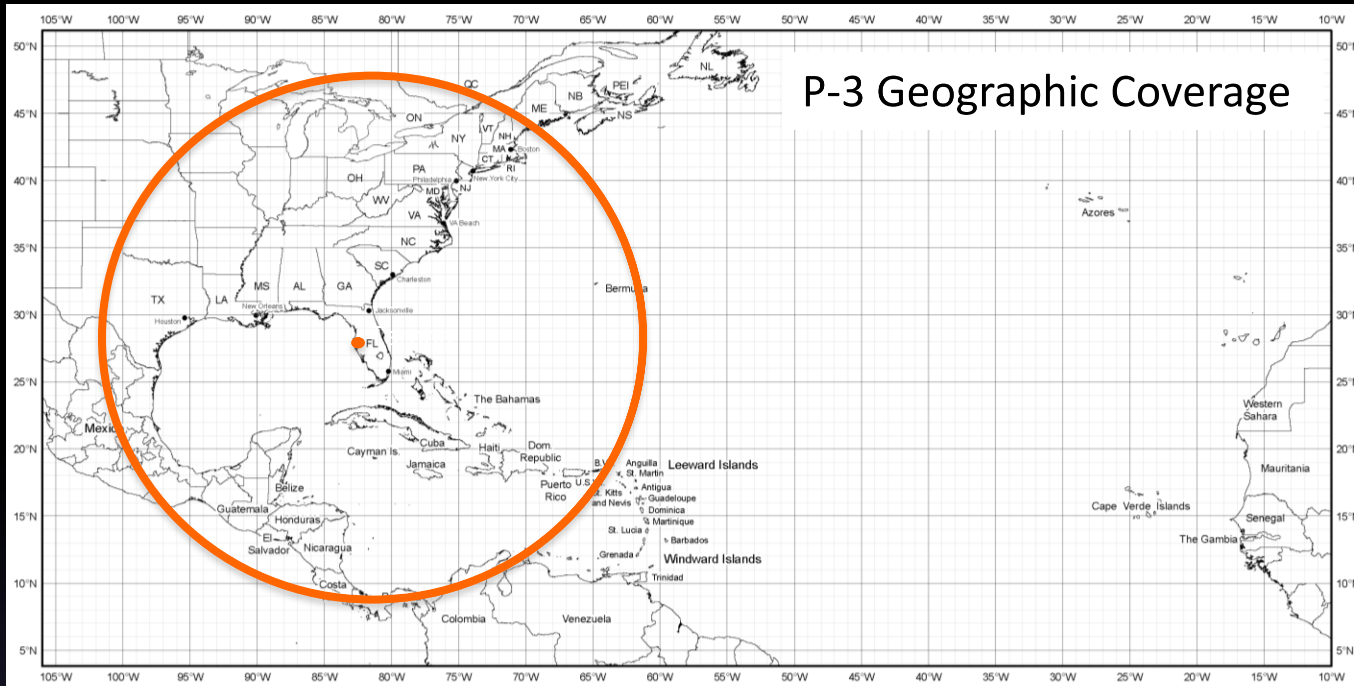
Atmospheric Scales	
Micro	mm - cm
Turbulent	m – km
Convective	100 m – 5 km
Vortex	1 – 100 km
Environment	100-10,000 km

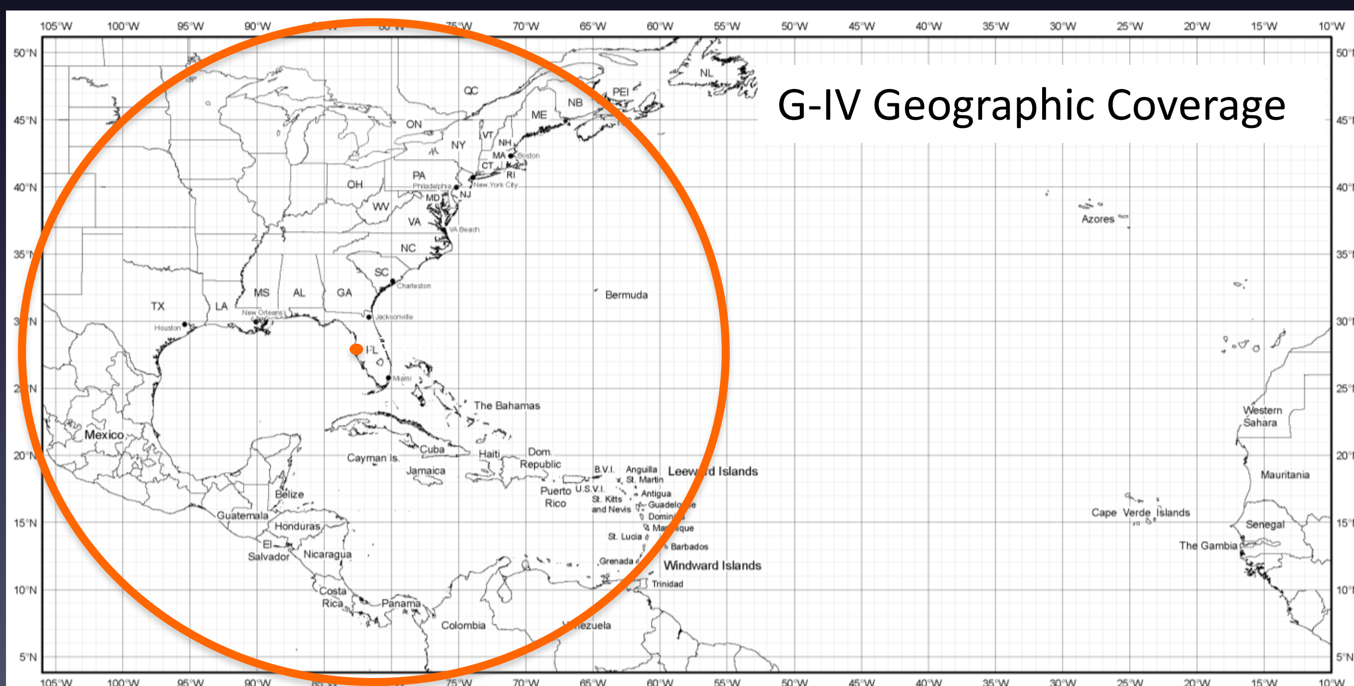
IFEX 2012 Flight Experiments



2012 HRD Field Program IFEX Plans

- Continuation of IFEX objectives
- Crews available for two-per-day P-3 missions, 2 G-IV mission per day
  - 1 P-3 available this season (N42RF)
    - WSRA (1st half of season) and IWRAP (2nd half of season)
    - ASPEN, RVP-8, and AAMPS *new!*
- Fly *operationally tasked* missions
  - Based on EMC's and/or NHC's operational need
  - Selected modules may be attempted


P-3 Geographic Coverage


G-IV Geographic Coverage

Three-dimensional Doppler Winds Experiment
P-3 TDR

PIs: John Gamache, Vijay Tallapragada, Peter Dodge, Paul Reasor, Sylvie Lorsolo, Altug Aksoy

Purpose: Provide a comprehensive wind data set for initialization (including data assimilation) and validation of hurricane numerical simulations such as HWRF

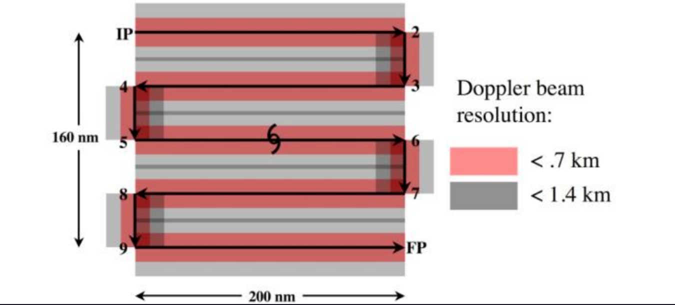
Plan: 2 P-3 Flights per day

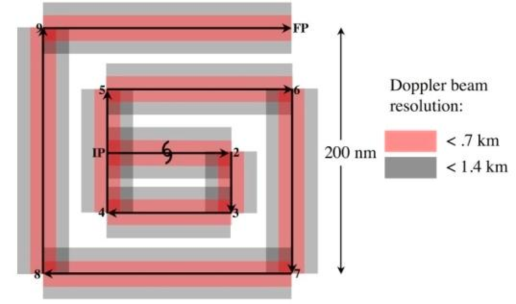
- on-station time centered on 12 and 0 UTC analysis periods (8 and 20 UTC take-off times)
- minimum 3 flights in a row starting at tropical depression or maybe pre-depression stage

P-3 TDR 3D Winds Experiment

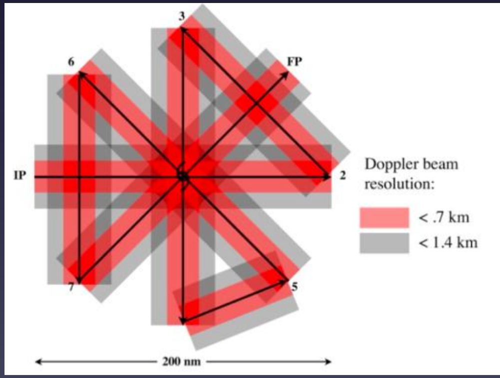
Typical flight patterns

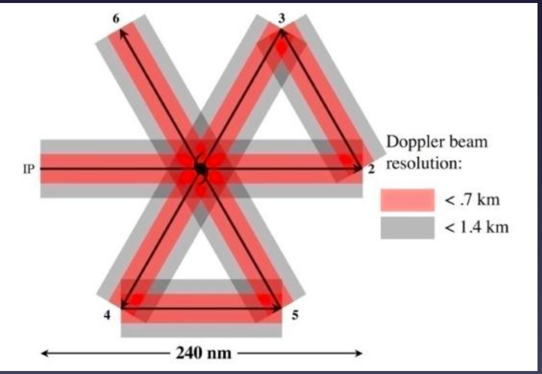
For pre-depression or depression stage

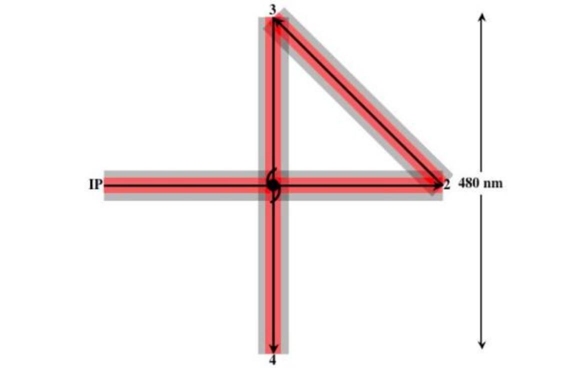




For tropical storm or hurricane stage







New this season…

G-IV TDR Experiment

PIs: John Gamache, Peter Dodge, Paul Reasor, Sylvie Lorsolo, Altug Aksoy

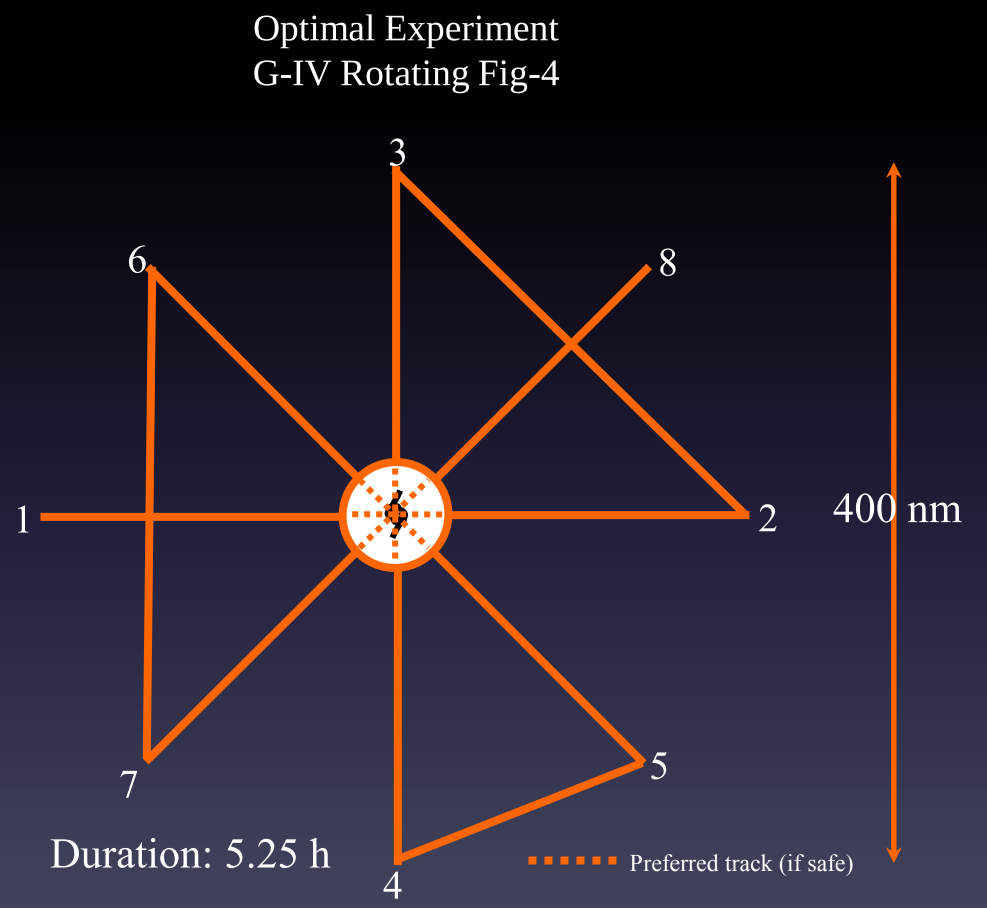
Objectives

- Evaluate the G-IV as a platform for observing the cores of TCs;
- Improve understanding of the factors leading to TC structure and intensity changes;
- Provide a comprehensive data set for the initialization (including data assimilation) and validation of numerical hurricane simulations (in particular HWRF);
- Develop rapid real-time communication of these observations to NCEP

G-IV TDR Experiment

Experiment Description

***Objective #1*: Evaluate the G-IV as a platform for observing the cores of TCs**



Note: When possible, NOAA P-3 aircraft will fly coordinated patterns with NOAA G-IV

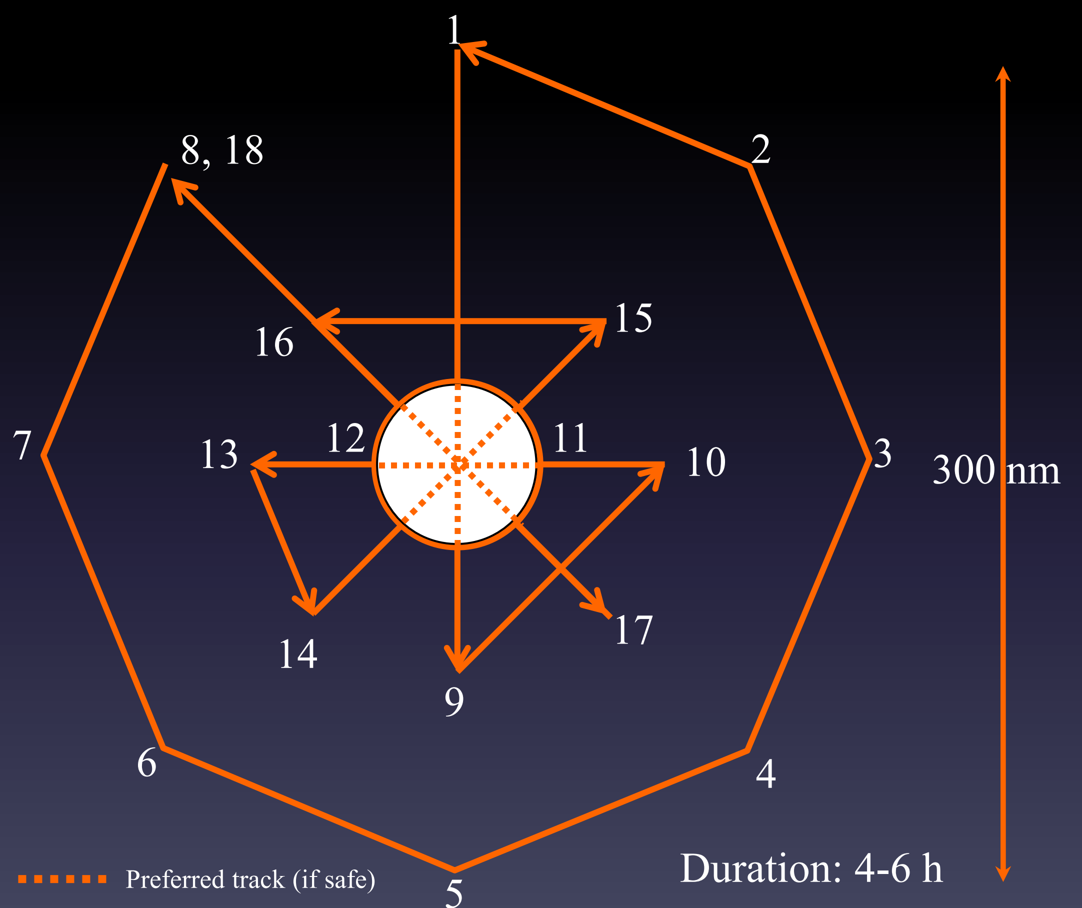
G-IV TDR Experiment

Experiment Description

***Objective #1*: Evaluate the G-IV as a platform for observing the cores of TCs**

Optimal Experiment
G-IV Surveillance/TDR
Combination

Dropsondes at 1-8



Duration: 4-6 h

Note: When possible, NOAA P-3 aircraft will fly coordinated patterns with NOAA G-IV

G-IV TDR Experiment

Questions

• How do core region winds from the G-IV TDR compare with those from the P-3?

• How much of the outflow structure does the G-IV TDR sample?

• What is the additional value of data from the G-IV TDR? (Assessed through HEDAS)

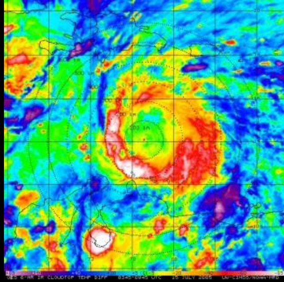
• What is the optimal flight pattern for combined G-IV surveillance and TDR? (Addressed through CHART project)

• How viable is the G-IV as a substitute for the P-3 in terms of TDR sampling?

• Since coordination with the P-3 is an early requirement, how do we weigh this experiment against others that require staggered P-3 and G-IV flights?

TC Diurnal Cycle Experiment

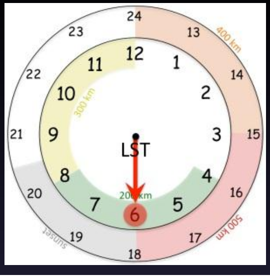
PI: Jason Dunion

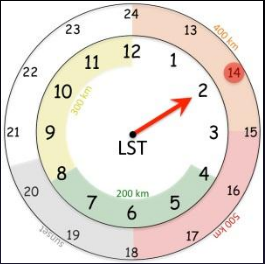


Scientific Objectives:

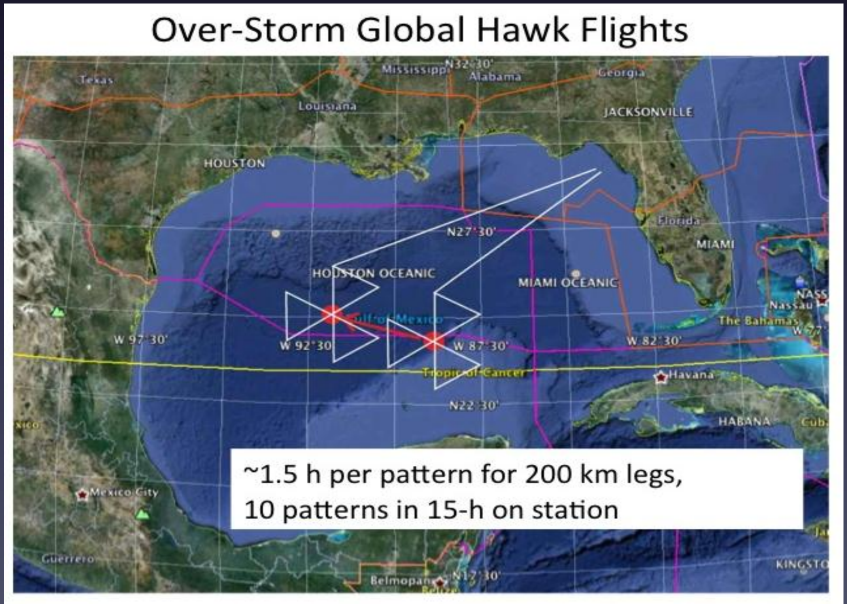
1)Collect kinematic and thermodynamic observations both within the inner-core (i.e., radius < 200 km) and in the surrounding large-scale environment (i.e., 200 km < radius < 500 km) for systems that have exhibited signs of diurnal pulsing in the previous 24 hours;

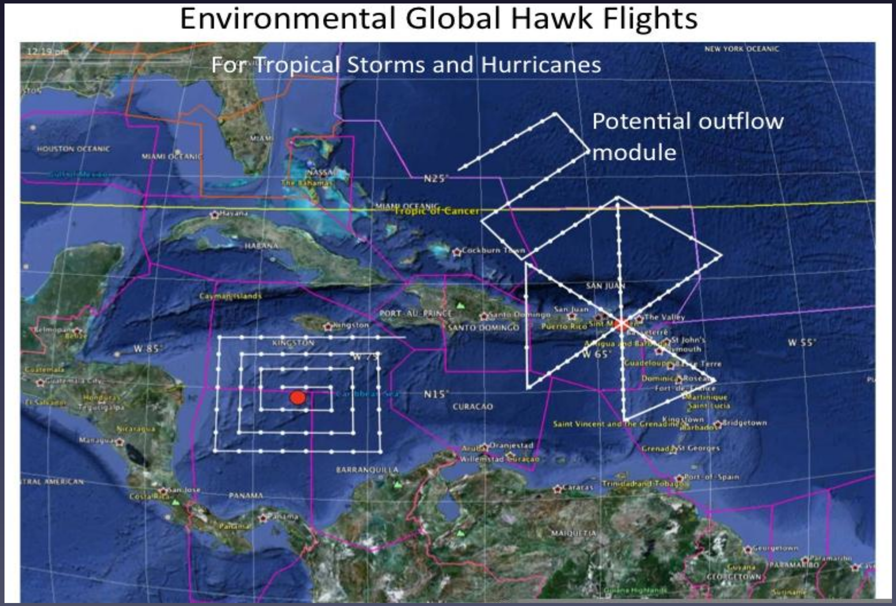
1)Improve the understanding, evolution, and prediction of TC diurnal cycle events;





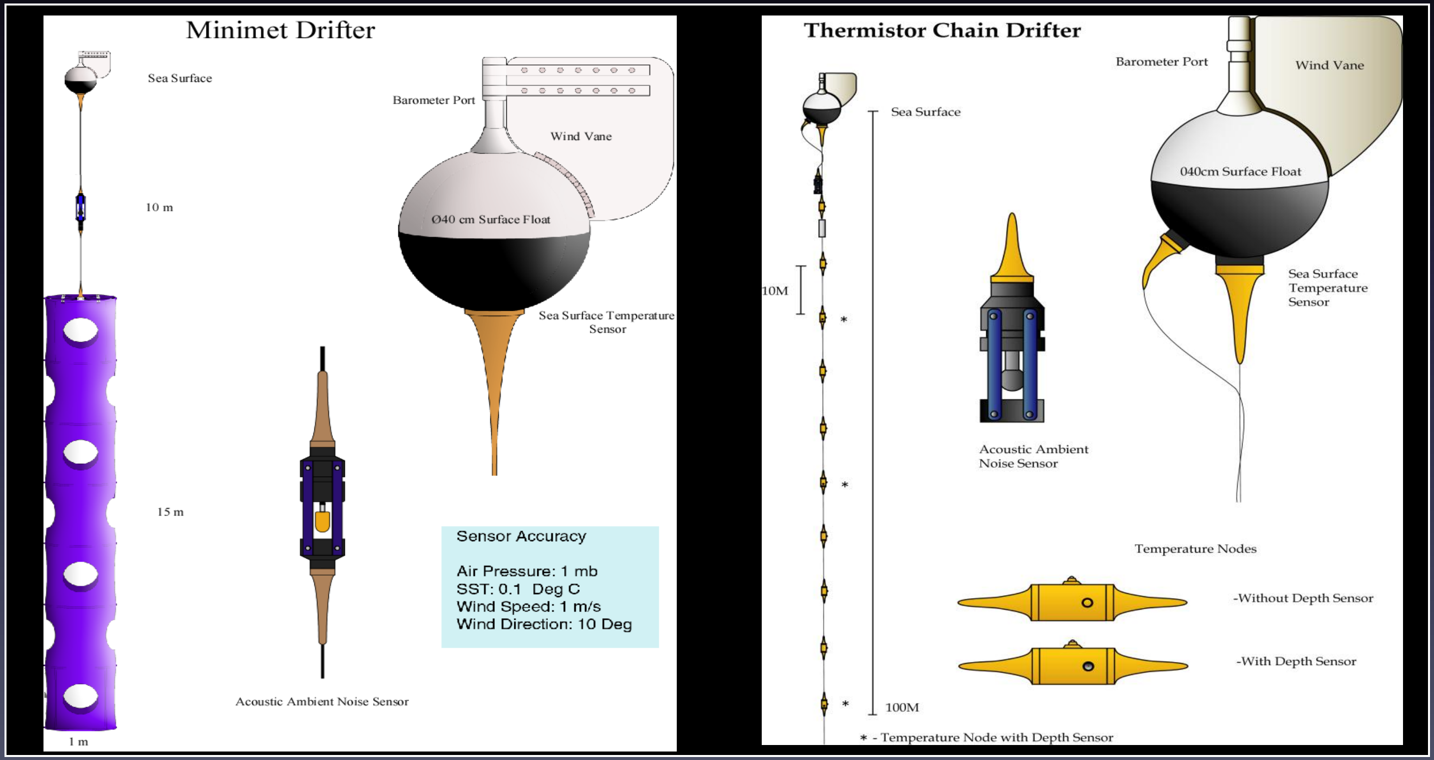
Diurnal pulse timing (LST) at the (left) ~200 km and (right) ~400 km radii





Float/Drifter Deployments

- PI: Rick Lumpkin (AOML/PhOD) and Luca Centurioni (SCRIPPS)
- Deploy drifters in the Gulf of Mexico and Caribbean
- Coordinate with 53rd and CARCAH



NASA's Hurricane & Severe Storm Sentinel (HS3)

A multi-year investigation of Atlantic hurricanes

- Science objective: environmental and storm-scale processes on intensity change
- 2012 time window: Sept. 1 - Oct. 5
- Operate out of Wallops Island, VA
- 2 Global Hawks (storm environment and over-storm flight)
- *Collaborate with NASA on flight pattern to maximize data coverage and continuity*

2012 Hurricane Field Program Logistics

Daily Schedule

- 9AM Conf call/meeting with IFEX participants *(if needed)*
- 10AM NOAA and NASA HS3 PIs telecon (Sept- Oct)
- noon Wx Discussion
- 1PM AOC telecon *(if needed)*

- HRD daily map discussions (25 July-29 October)
  - noon start time
  - goto meeting info available
- Daily blog/email update *(when field activities are occurring)*

Communicating in the field

- Our blog

http://noaahrd.wordpress.com

- HRD Web page

http://www.aoml.noaa.gov/hrd

- Facebook

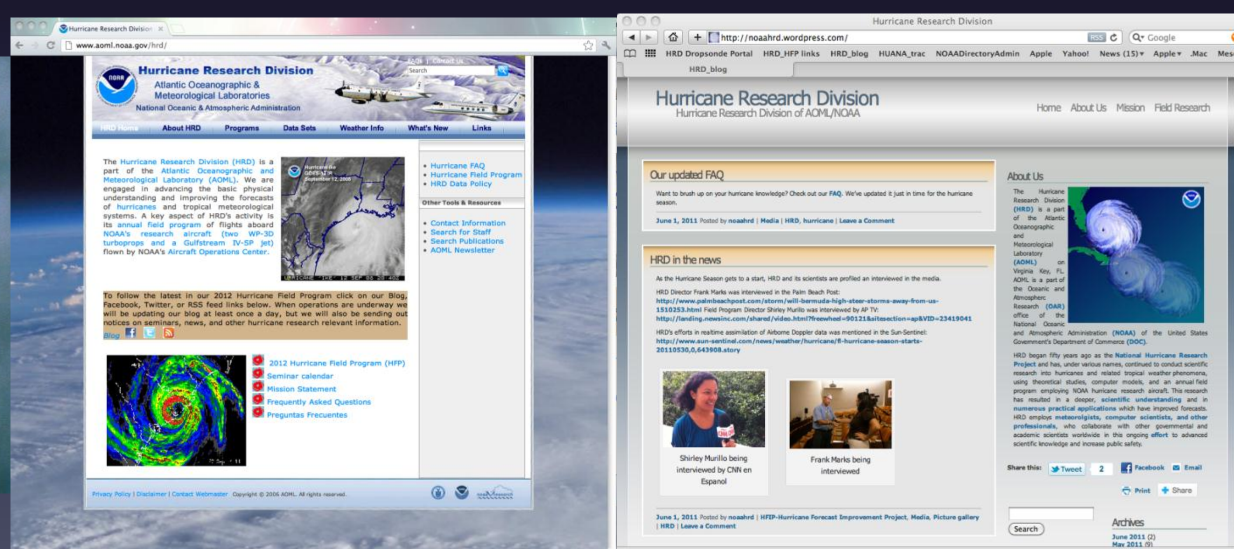
http://www.facebook.com/noaahrd

- Twitter

http://twitter.com/hrd_aoml_noaa

follow us on twitter

Thank you!



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