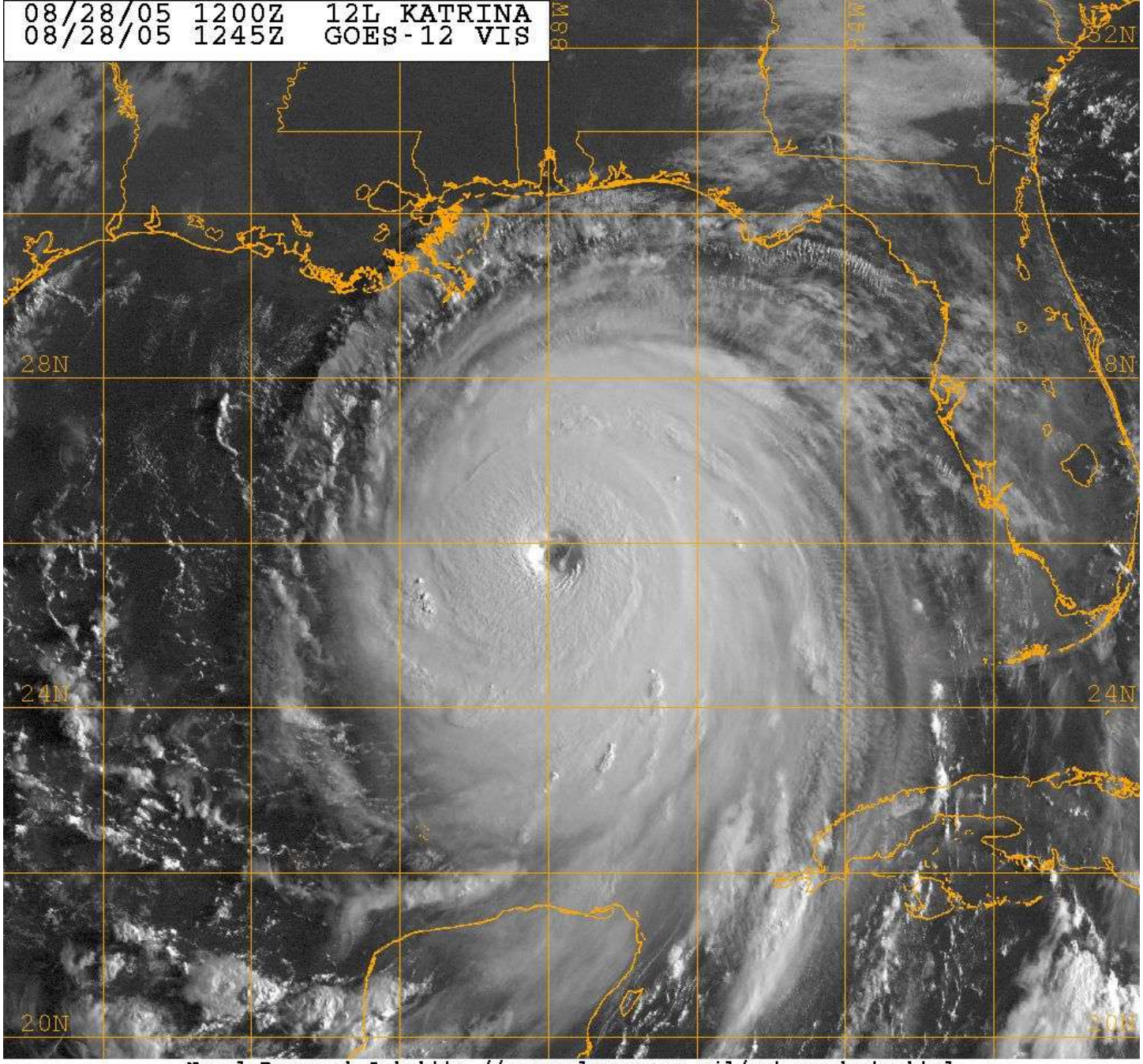
South Carolina State Climate Office

HURRICANES 101:
For the Prudent Mariner

Mark Malsick
Severe Weather Liaison



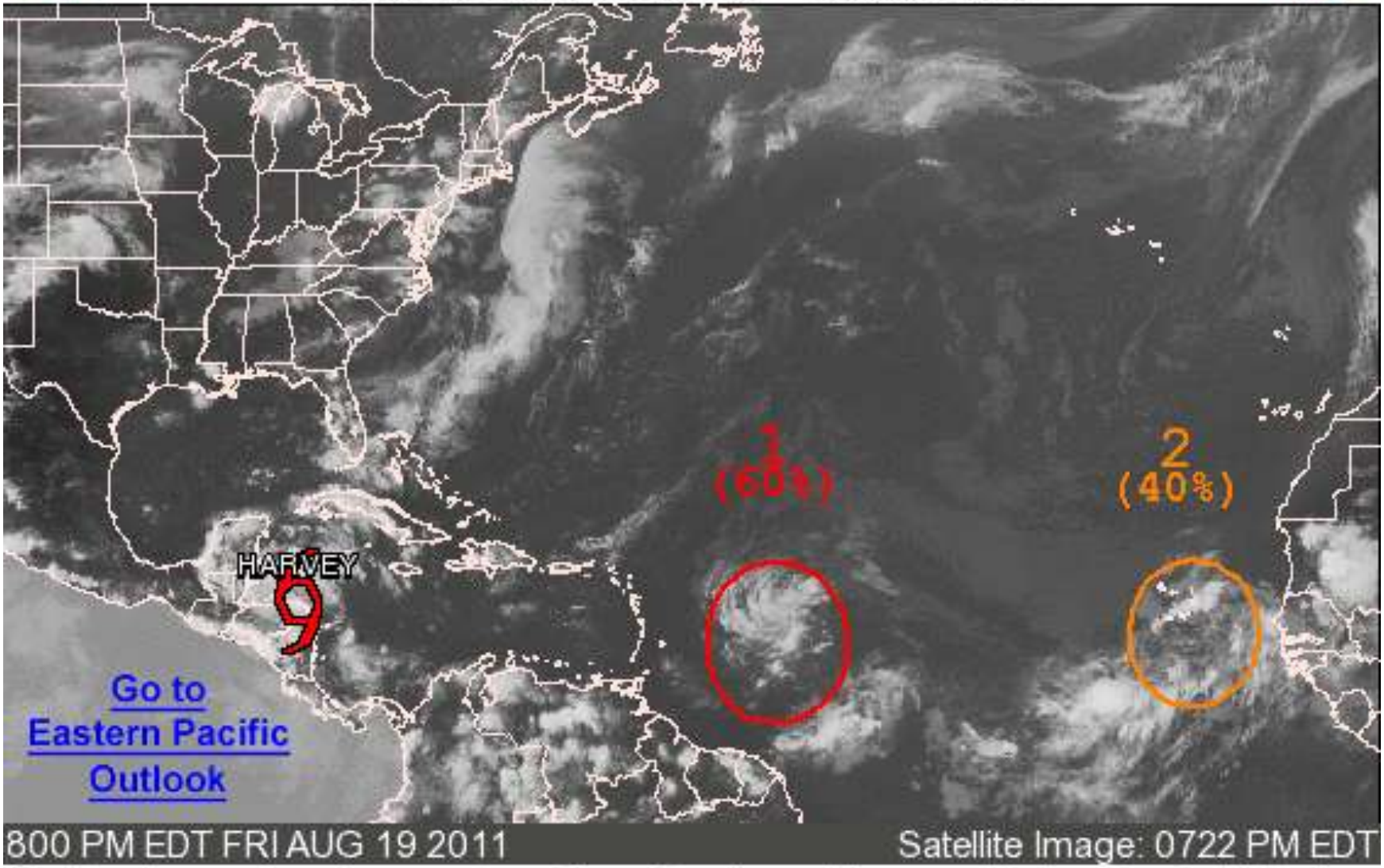
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 17 degrees) -->

NATIONAL HURRICANE CENTER

www.nhc.noaa.gov

Graphical Tropical Weather Outlook

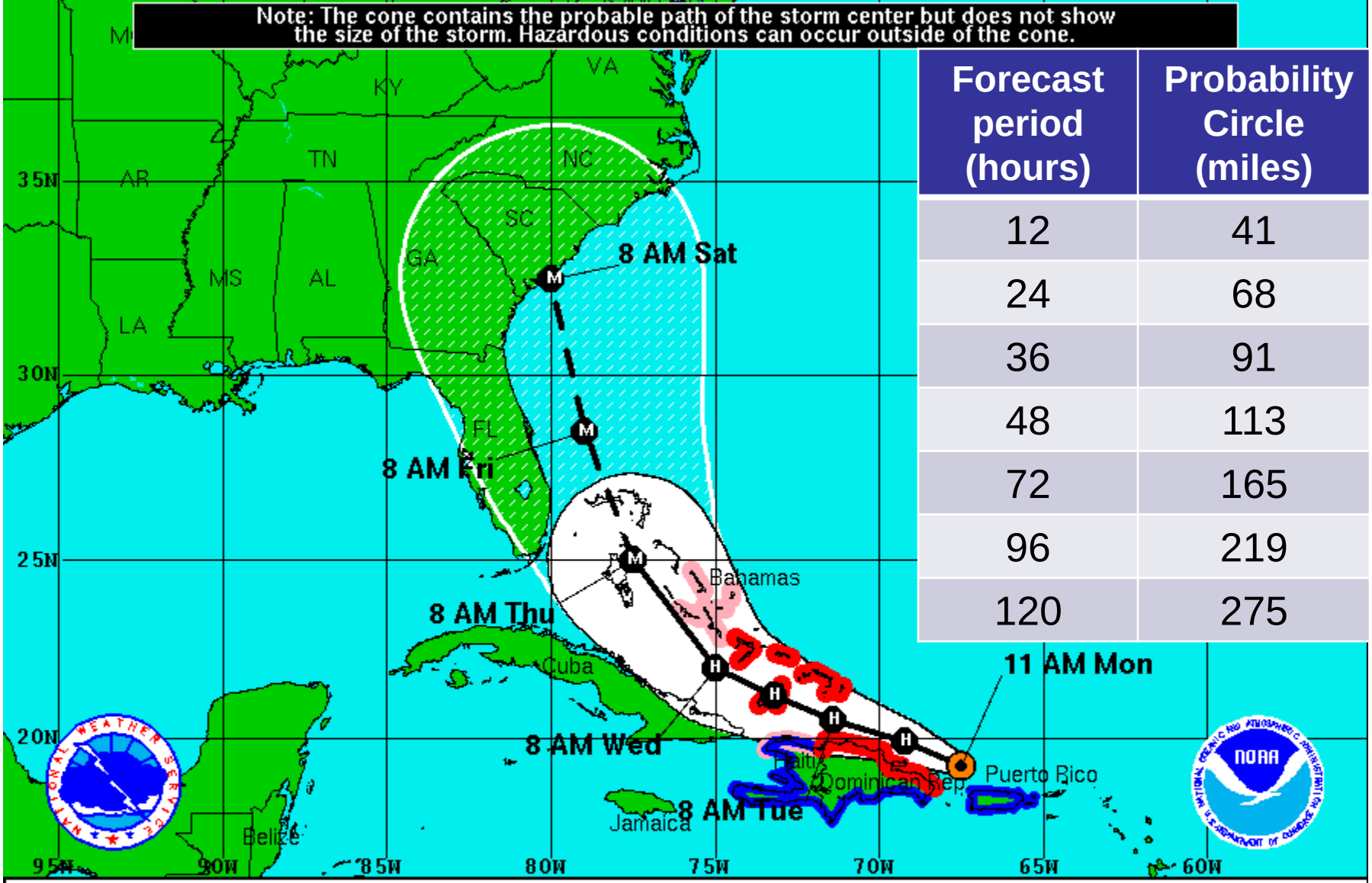
National Hurricane Center Miami, Florida



Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <30% Medium 30-50% High >50%

Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.



Forecast period (hours)	Probability Circle (miles)
12	41
24	68
36	91
48	113
72	165
96	219
120	275

Hurricane Irene
Monday August 22, 2011
11 AM EDT Advisory 8
NWS National Hurricane Center

Current Information:
Center Location 19.2 N 67.5 W
Max Sustained Wind 80 mph
Movement WNW at 13 mph

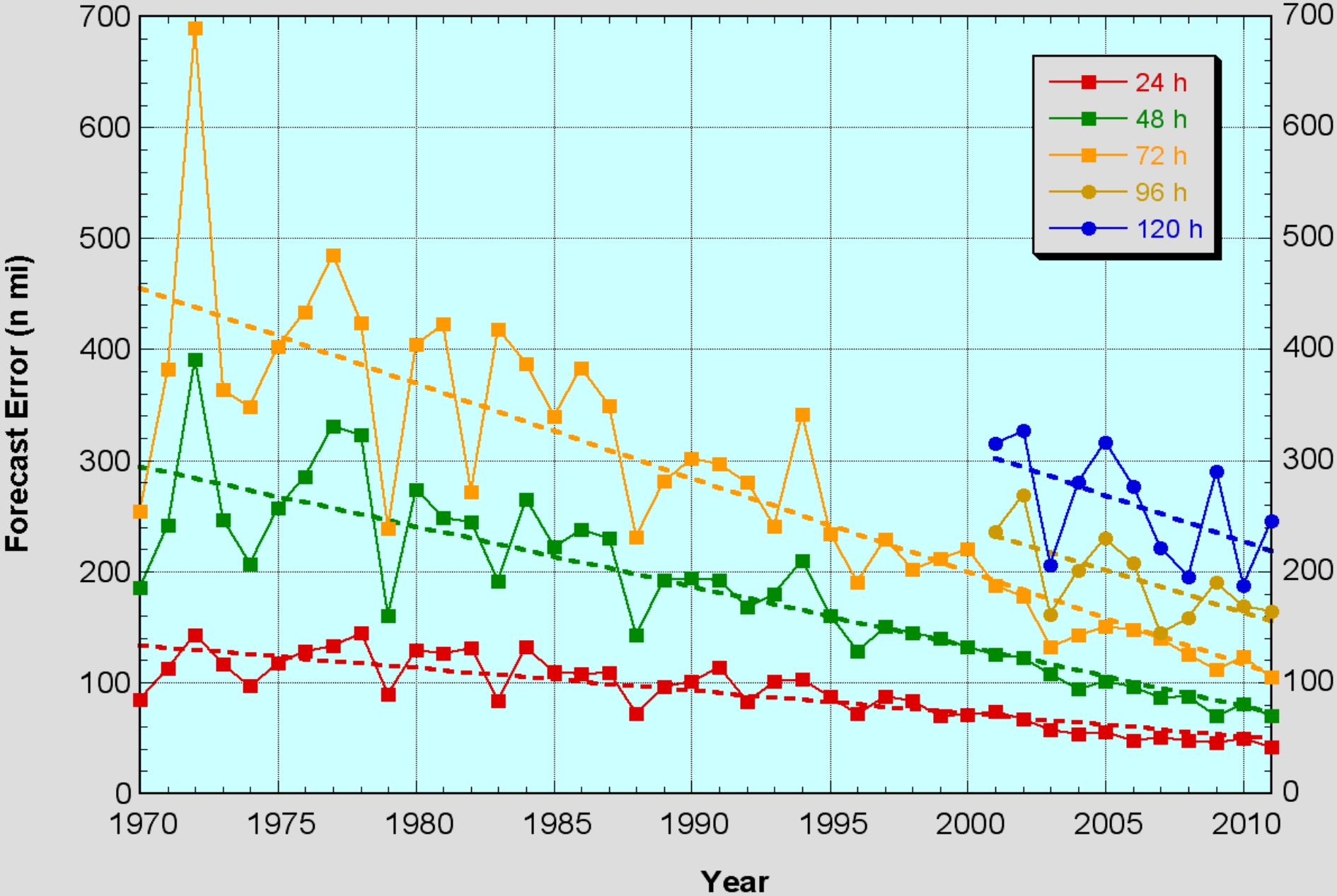
Forecast Positions:
Tropical Cyclone Post-Tropical
Sustained Winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110mph

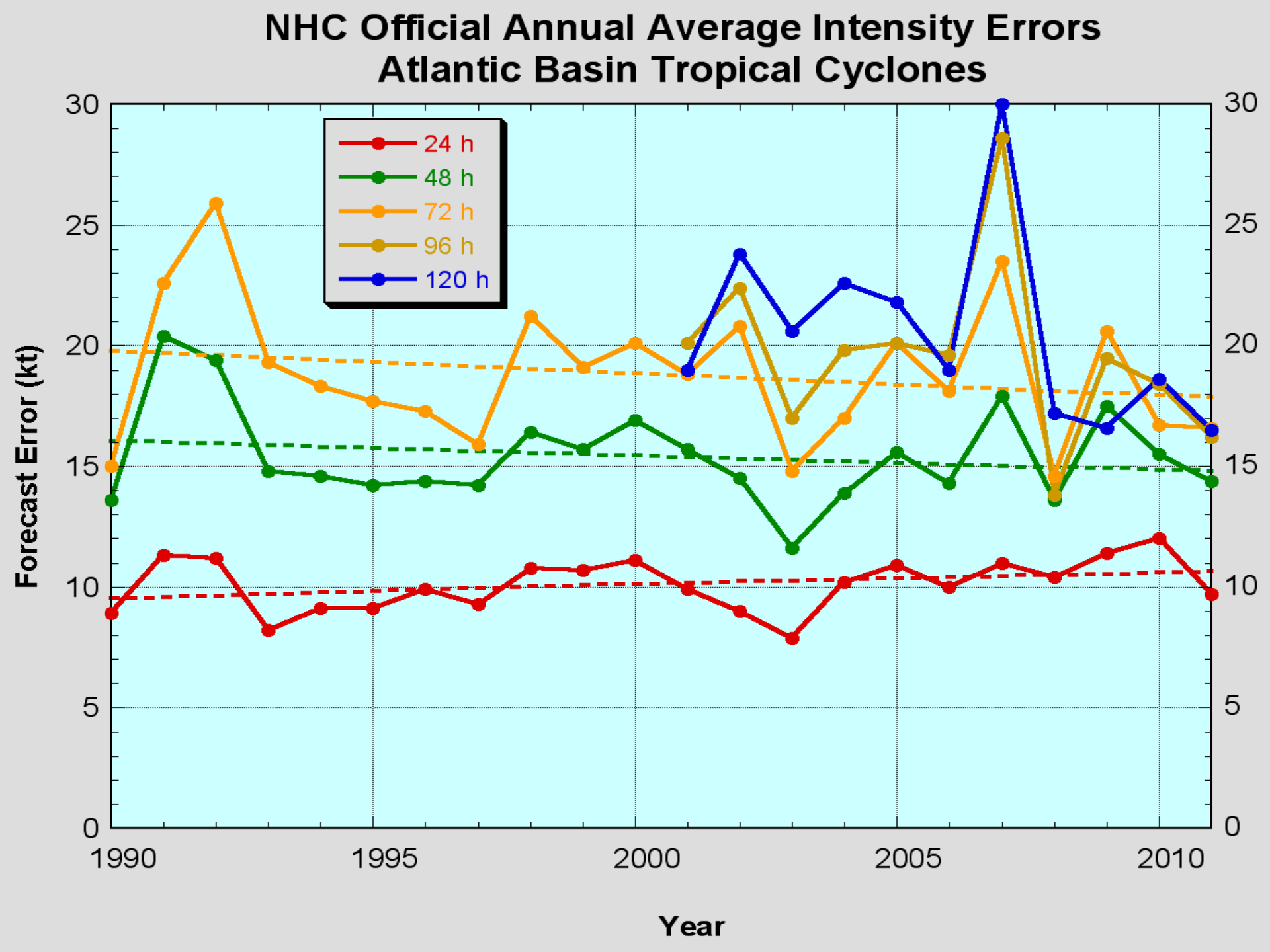
Potential Track Area:
Day 1-3 Day 4-5

Watches:
Hurricane Trop.Storm

Warnings:
Hurricane Trop.Storm

NHC Official Annual Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes




NHC Official Annual Average Intensity Errors
Atlantic Basin Tropical Cyclones
24 h
48 h
72 h
96 h
120 h
Forecast Error (kt)
Year
0
5
10
15
20
25
30
1990
1995
2000
2005
2010

CATEGORY 1

IRENE 2011

WINDS: 74 to 95 mph (64 - 82kts)

DAMAGE:

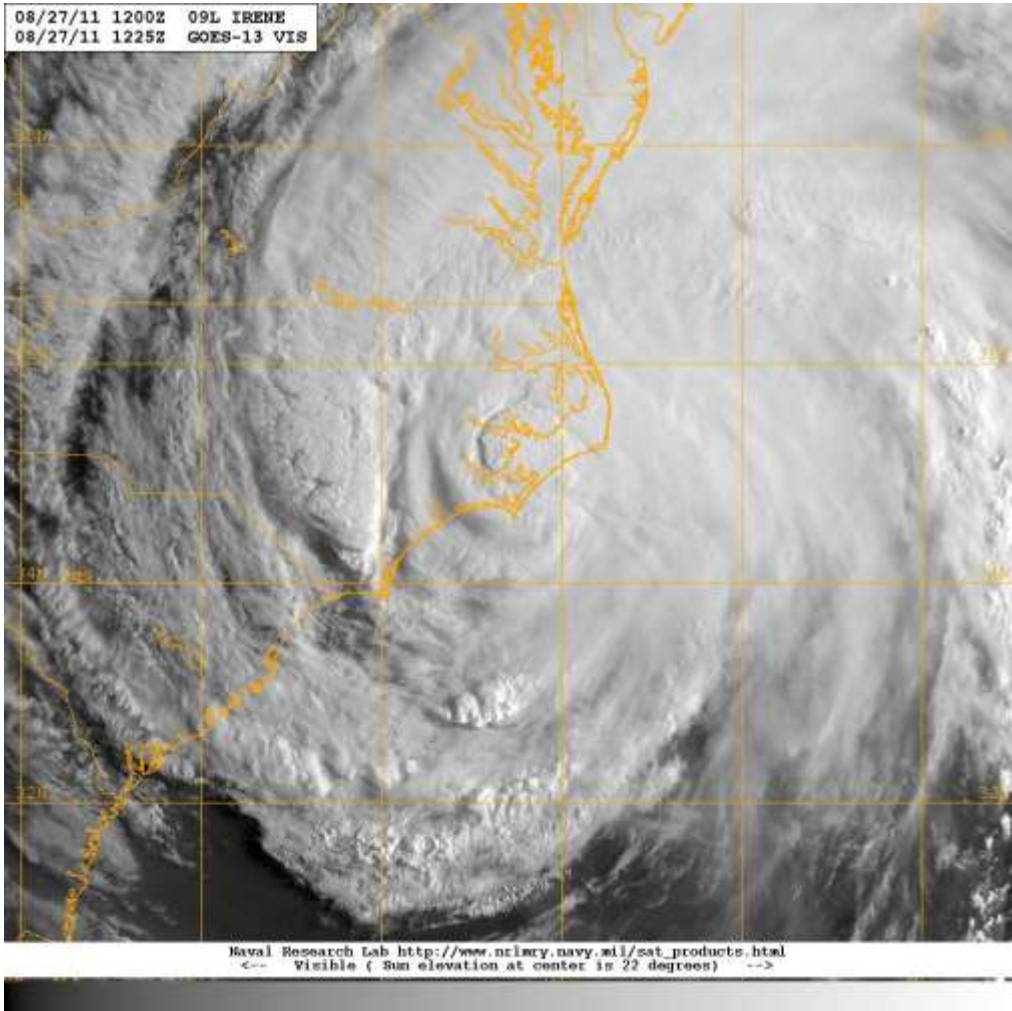
BRANCHES DOWN

POWER LINES

ROOF AND SIDING

COASTAL FLOODING

MINOR PIER DAMAGE



CATEGORY 2

WINDS: 96 to 110 mph
(83 – 95kts)

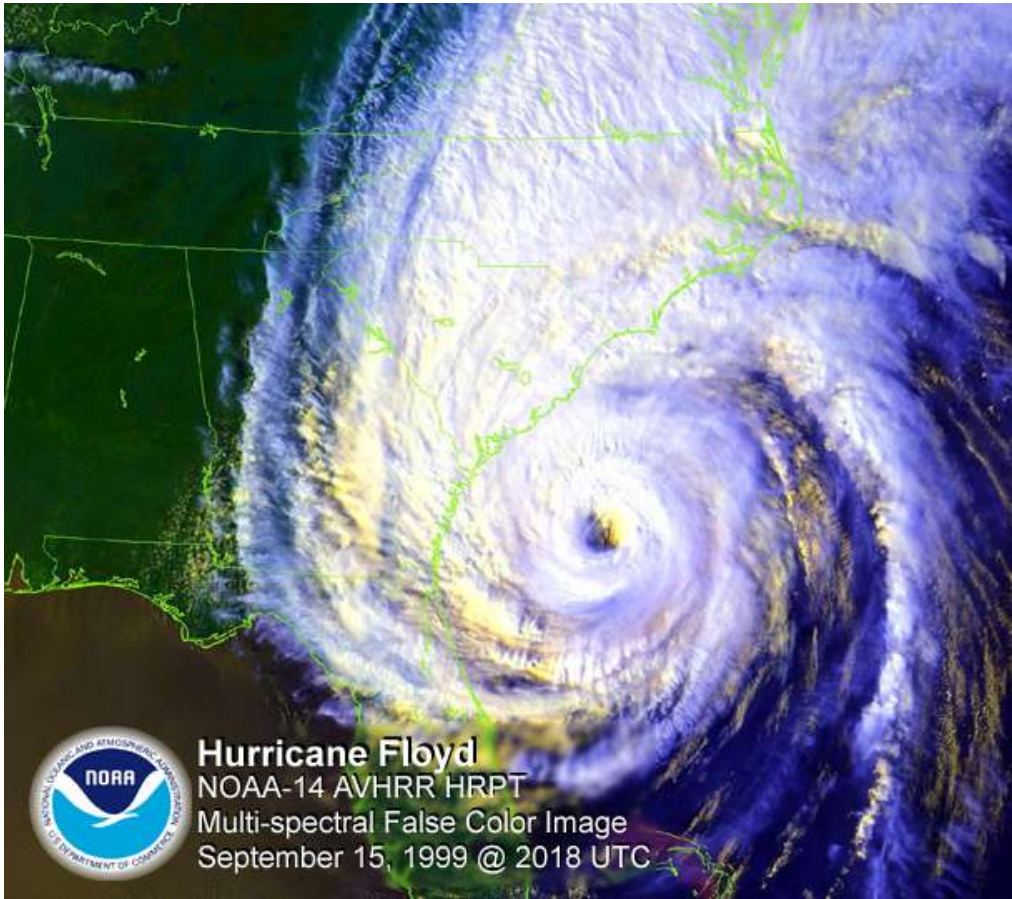
DAMAGE:

TREES BLOWN DOWN

BUILDINGS DAMAGED

COASTAL FLOODING

FLOYD 1999



CATEGORY 3

WINDS: 111 to 129 mph
(96 – 112kts)

DAMAGE:

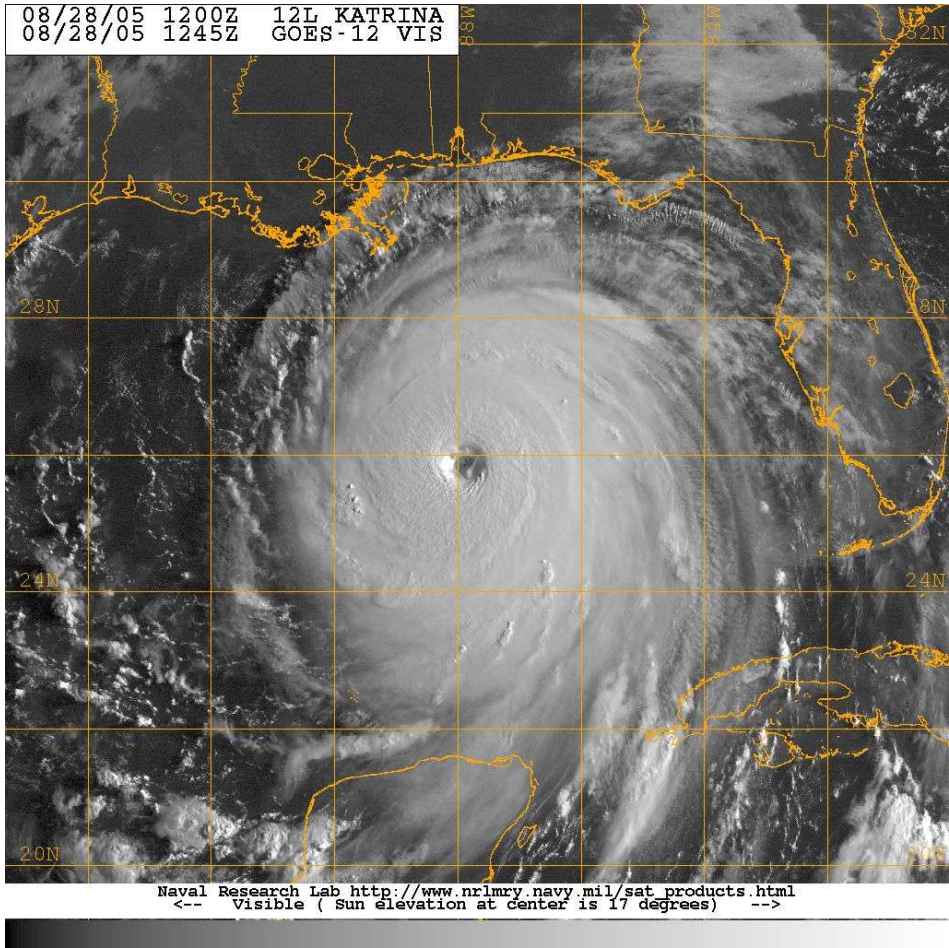
TREES BLOWN DOWN

MOBILE HOMES DESTROYED

INLAND FLOODING

SHORELINE EVAC REQUIRED

KATRINA 2005



CATEGORY 4

WINDS: 130 to 156 mph
(113 – 136KTS)

DAMAGE:

ALL TREES DOWN

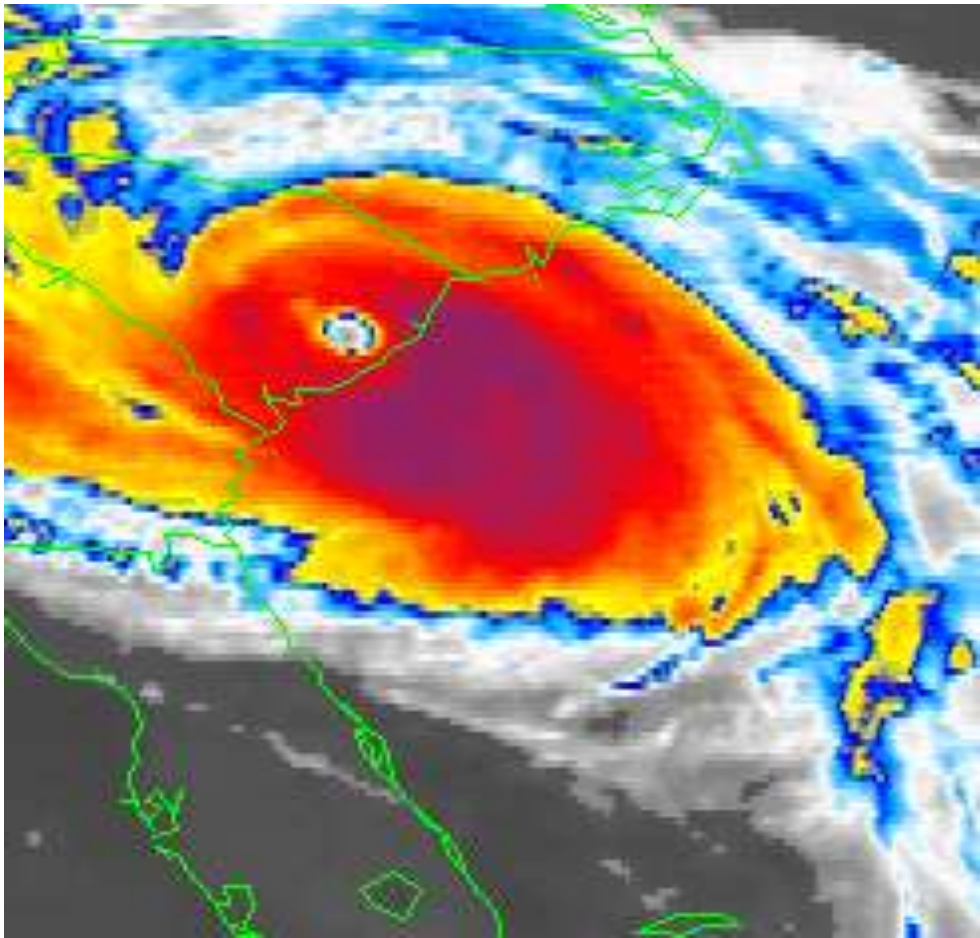
ROOFS BLOWN OFF

MOBILE HOMES GONE

INLAND FLOODING

EVACUATIONS

HUGO 1989



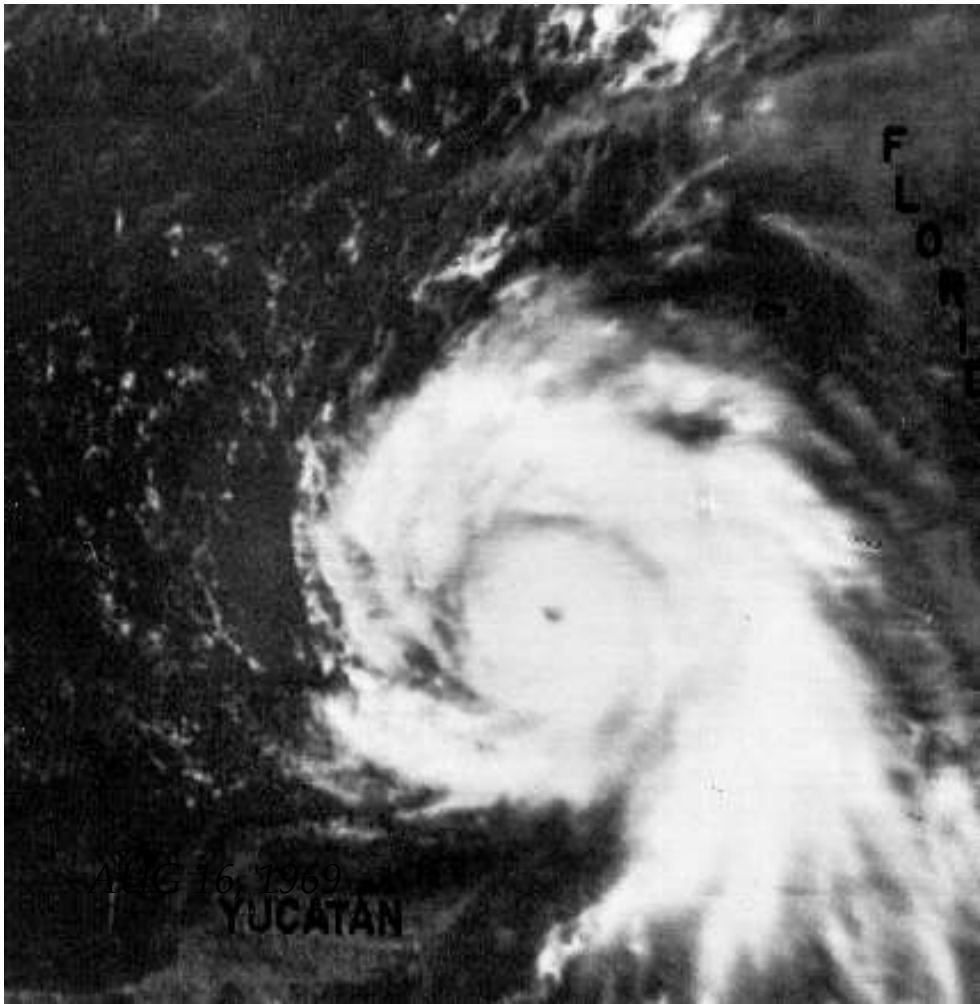
CATEGORY 5

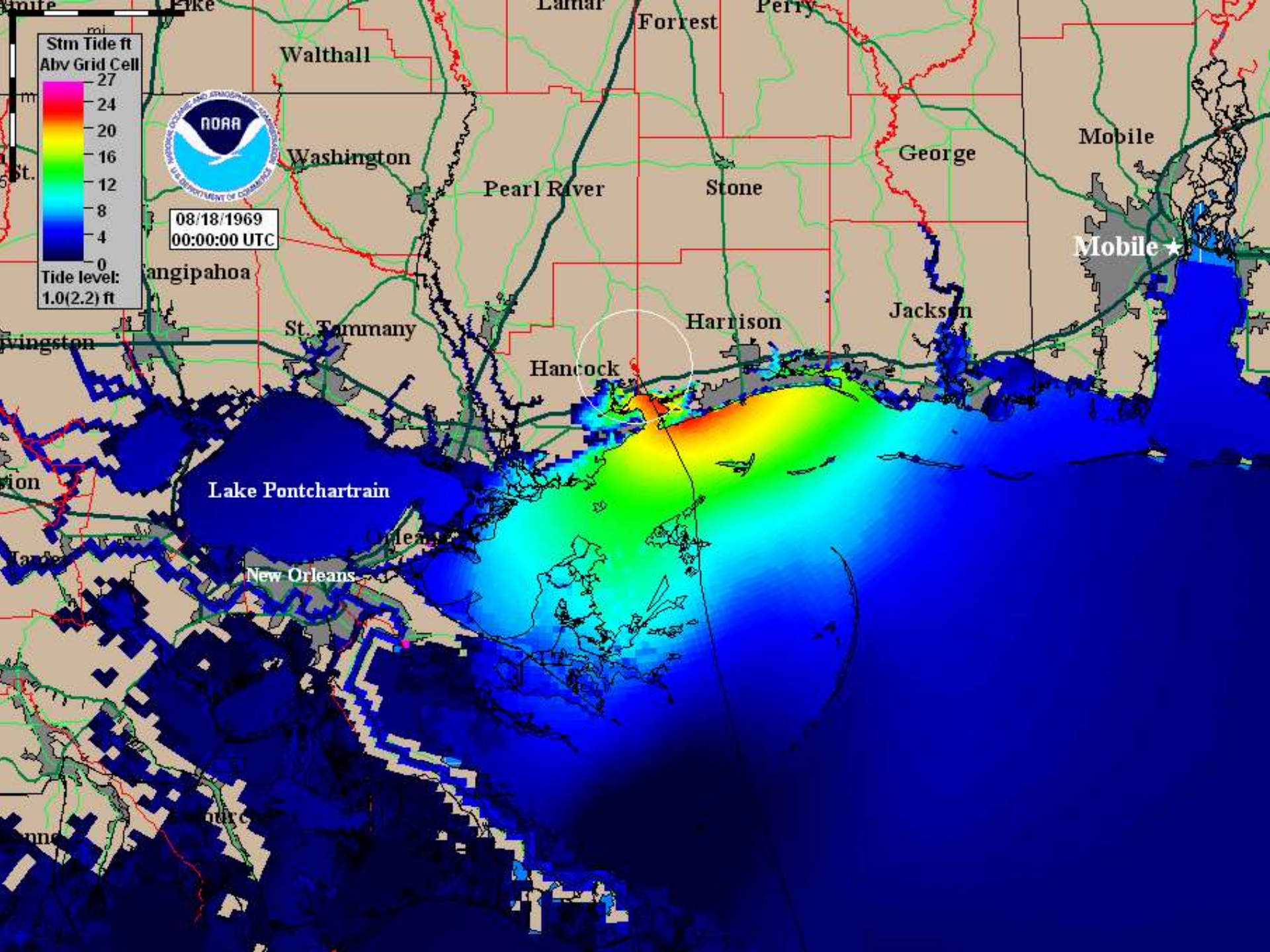
WINDS: >157 mph
(>137KTS)

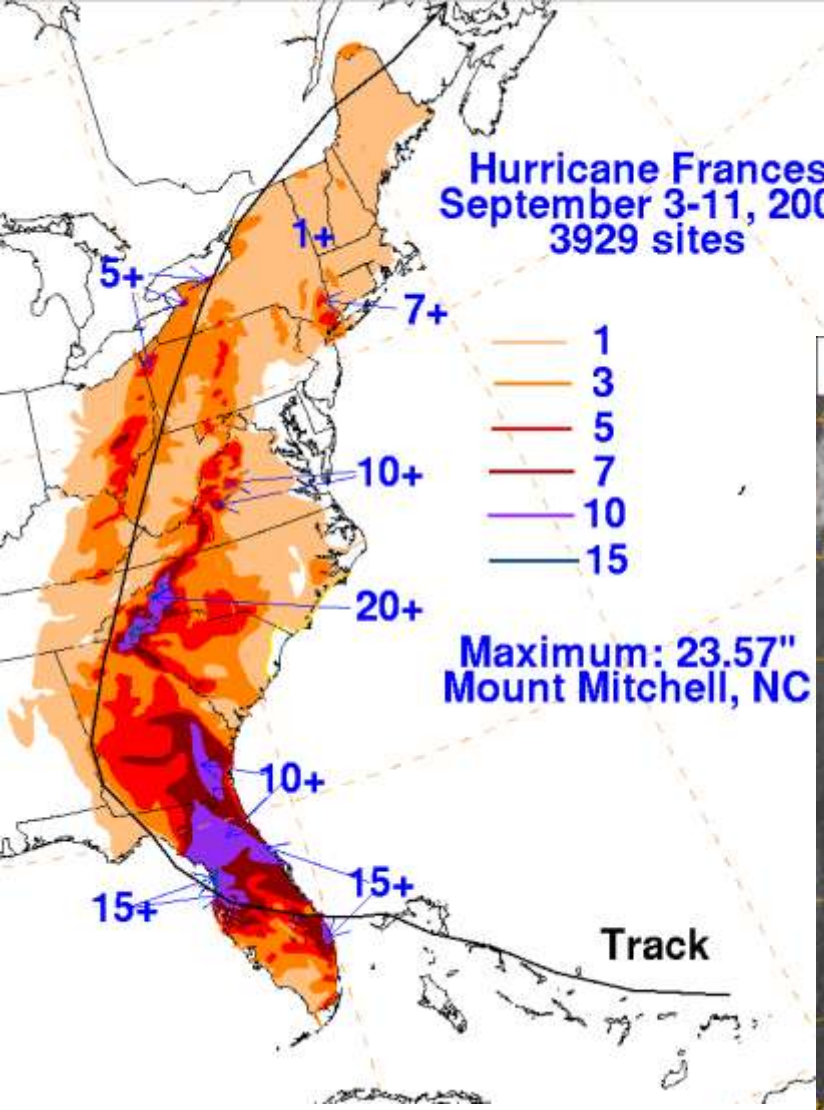
DAMAGE:

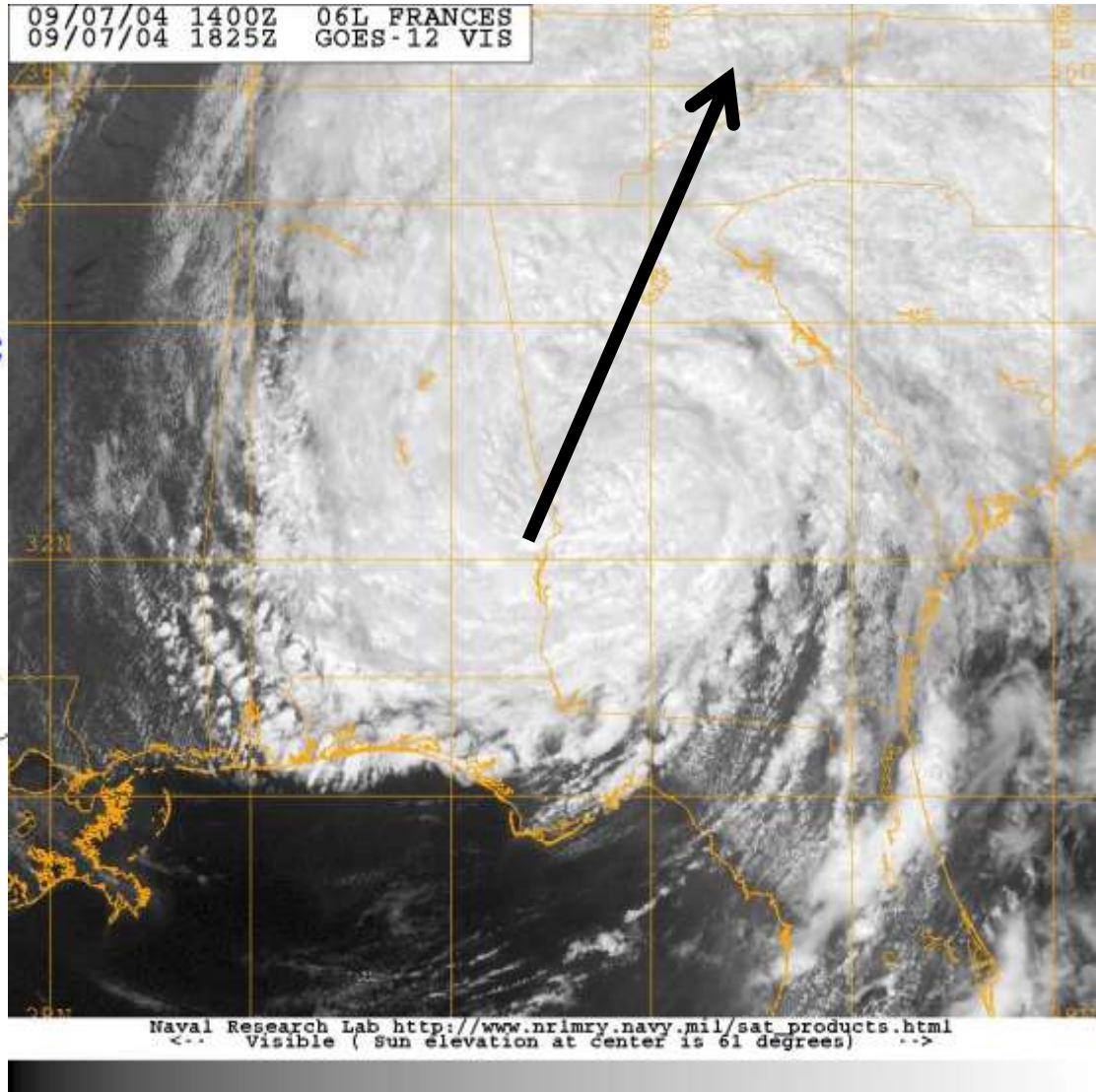
CATASTROPHIC DAMAGE
BUILDING FAILURES
SHORELINE STRUCTURES
DESTROYED

CAMILLE 1969




Stm Tide ft
Abv Grid Cell
27
24
20
16
12
8
4
0
Tide level:
1.0(2.2) ft
08/18/1969
00:00:00 UTC
Walthall
Lamar
Forrest
Perry
Washington
Pearl River
Stone
George
Mobile
Mobile ★
Harrison
Jackson
St. Tammany
Hancock
Lake Pontchartrain
New Orleans

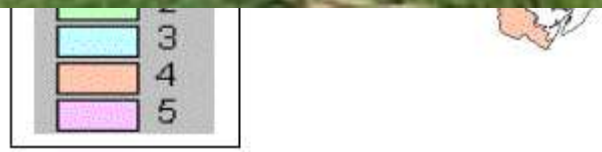

Hurricane Frances
September 3-11, 2004
3929 sites
1+
5+
7+
10+
20+
10+
15+
15+
1
3
5
7
10
15
Maximum: 23.57"
Mount Mitchell, NC
Track


09/07/04 1400Z 06L FRANCES
09/07/04 1825Z GOES-12 VIS
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- Visible (Sun elevation at center is 61 degrees) -->
32N

T.D. Frances Tornado Outbreak Statistics

September 6 – 7, 2004

(by county and intensity)



TROPICS

Large Sparsely Uninhabited Area (30N-30S)

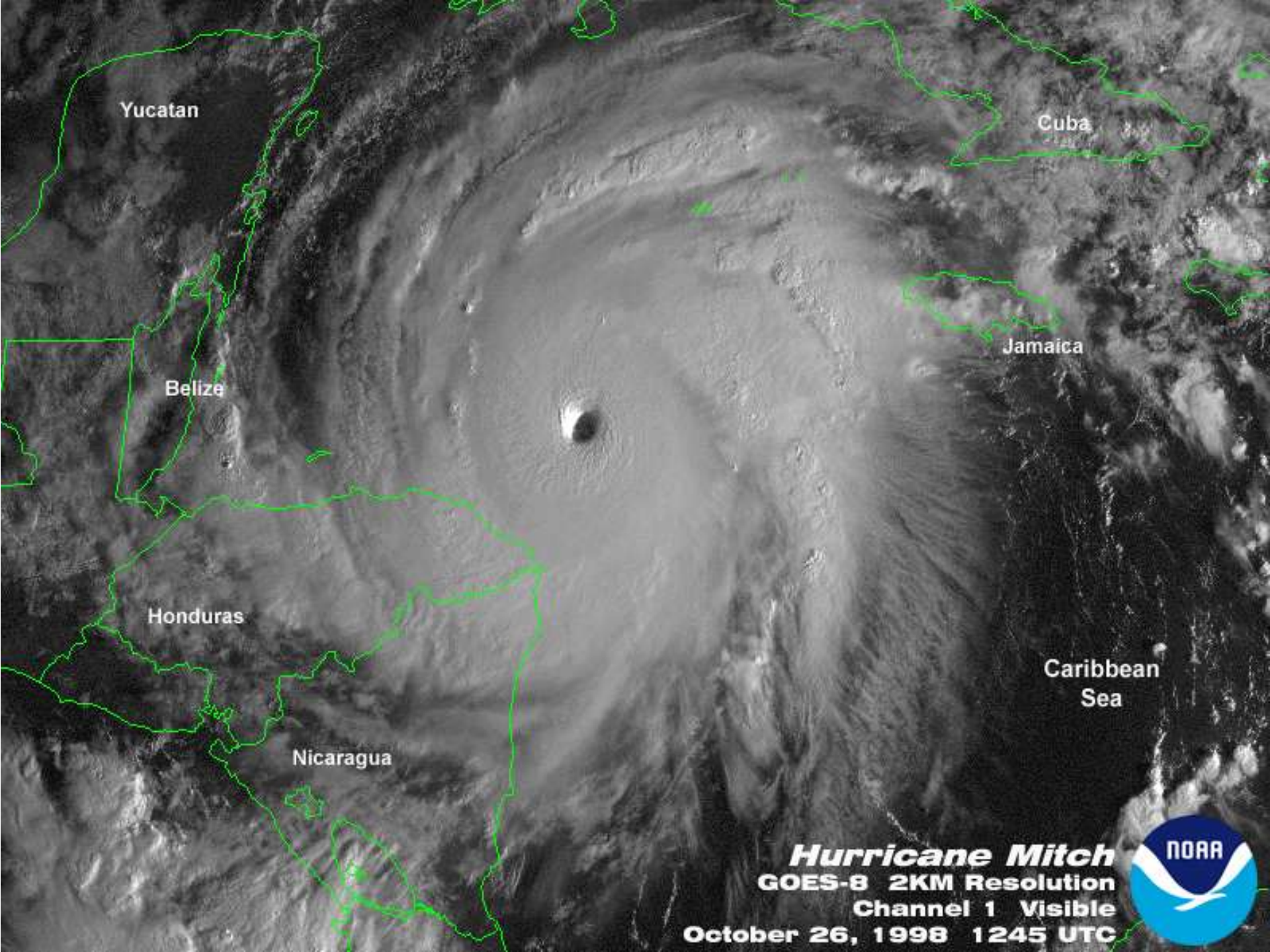
Data Sparse Region

Weak Pressure and Temperature Gradients

Weak Vertical Velocity Gradients

No Synoptic Features

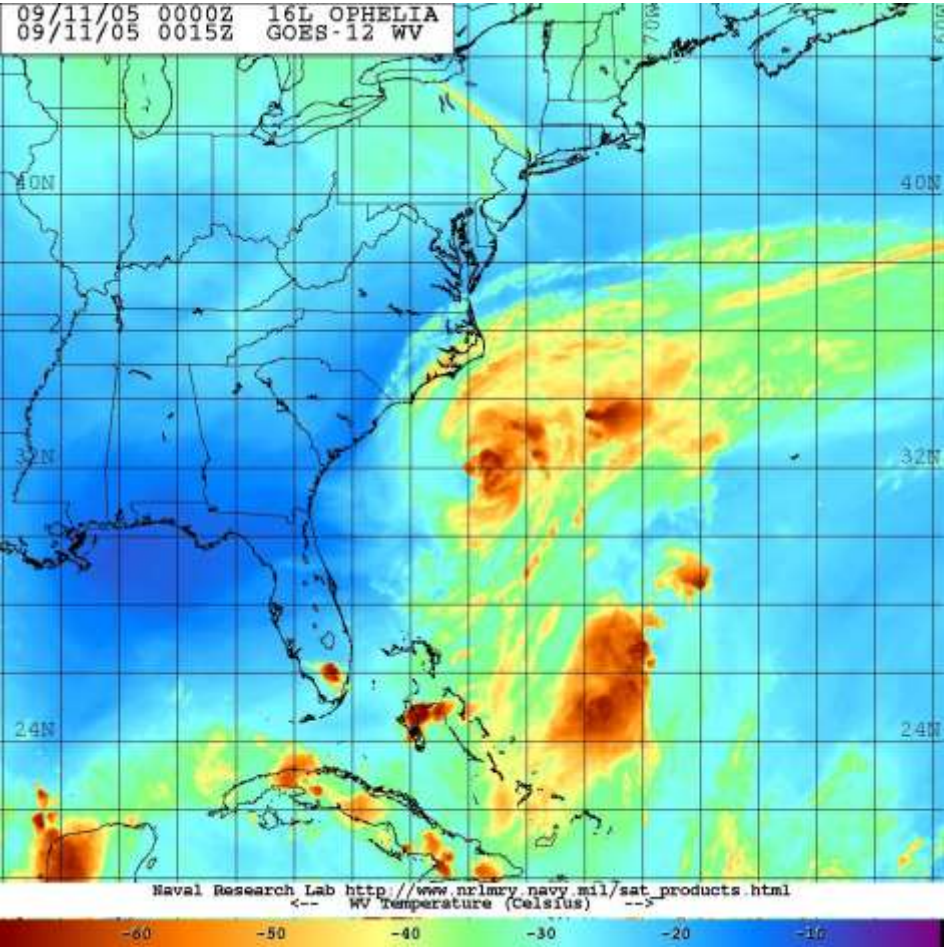
Air-Ocean Coupling


Yucatan
Cuba
Jamaica
Belize
Honduras
Caribbean
Sea
Nicaragua
Hurricane Mitch
GOES-8 2KM Resolution
Channel 1 Visible
October 26, 1998 1245 UTC
NOAA

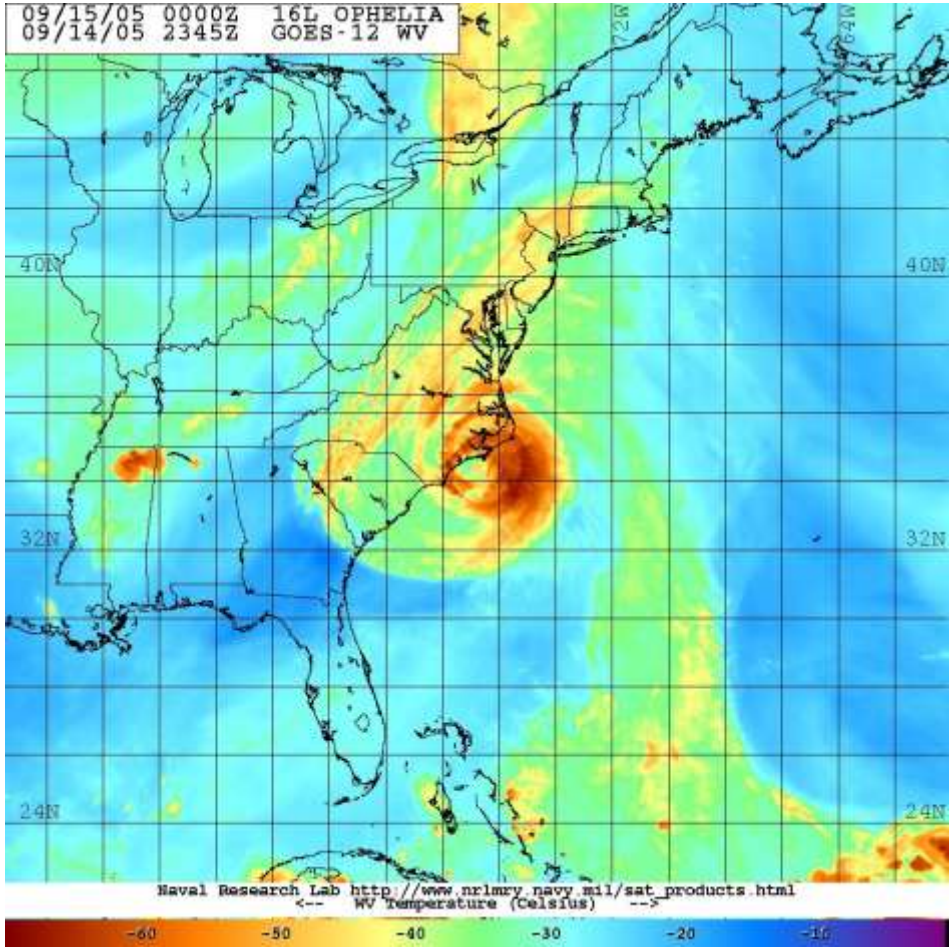
Hurricane Requirements:

1. SST and MLD (26.5 ^{o}C. and 60 m.)
2. Weak Vertical Wind Shear (<15kts)
3. Mid-Tropospheric Humidity
4. Divergent Upper Troposphere
5. Low Level Positive Relative Vorticity
6. Potentially Unstable Troposphere
   ($\Delta\theta_E$< 10° K between 1000mb and 500mb)
7. Earth's Vorticity (>3° north Latitude)

HURRICANE OPHELIA
DRY AIR ENTRAINMENT

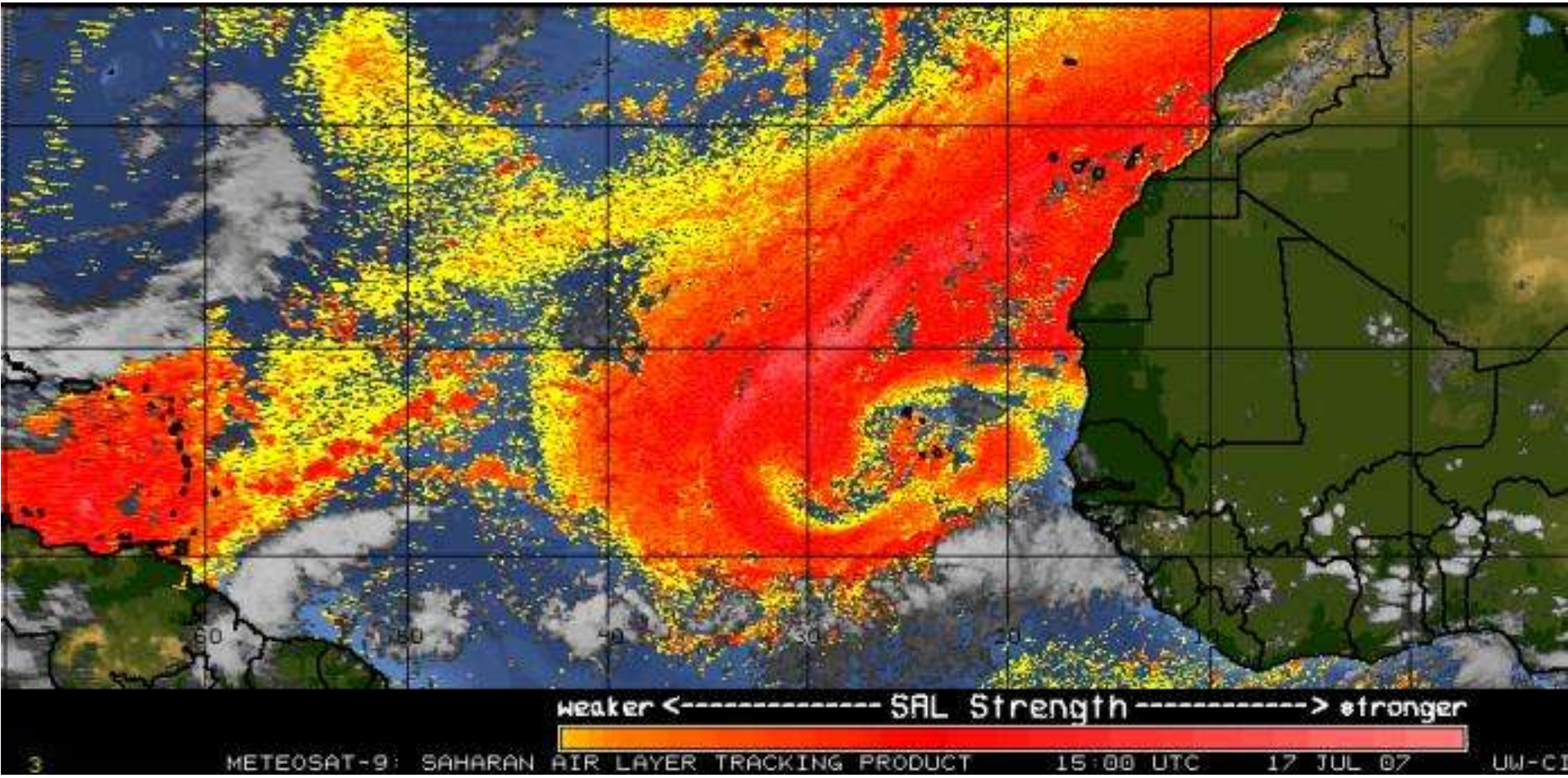


11 SEP 2005 70 KTS

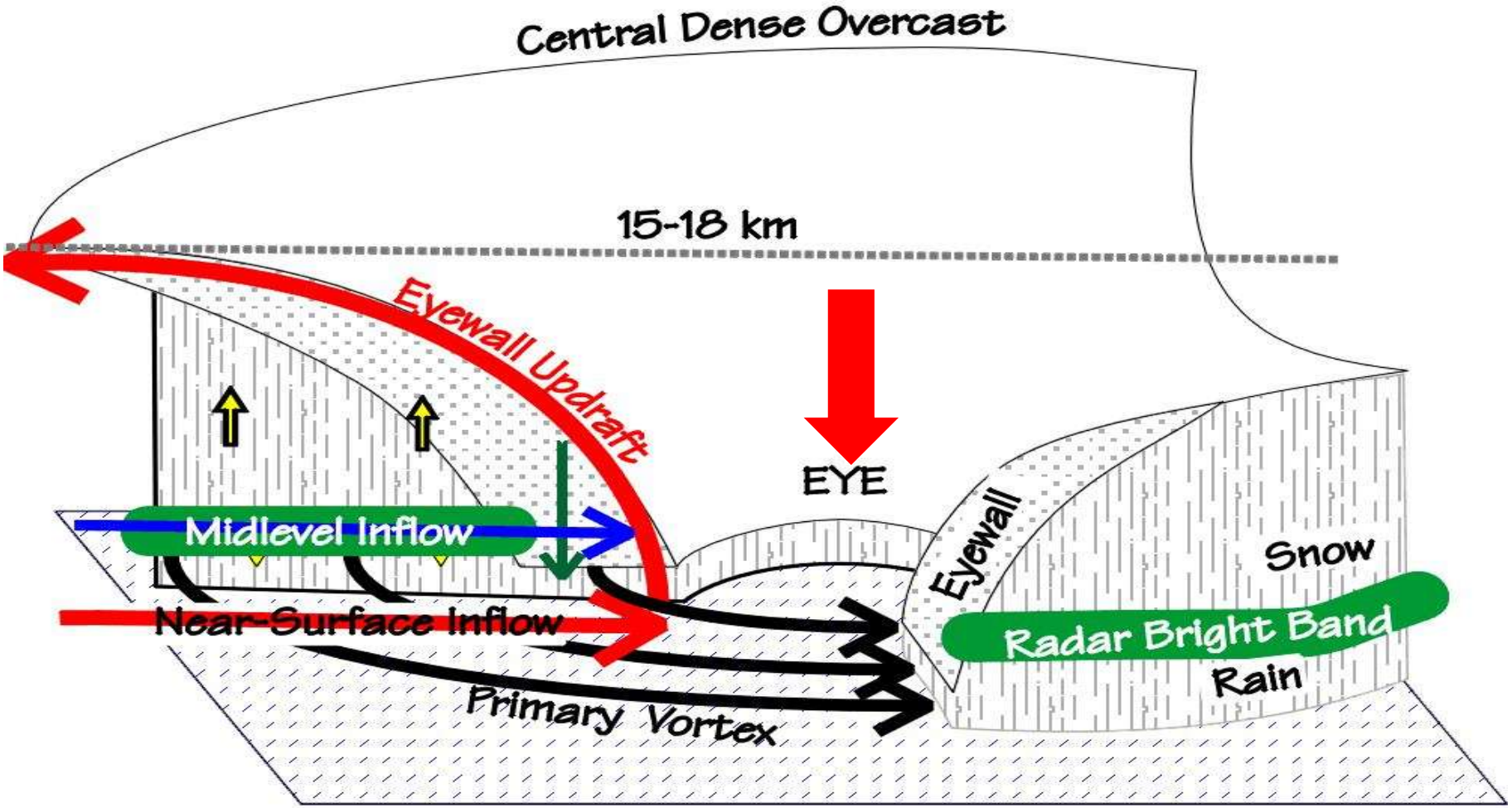


15 SEP 2005 75 KTS

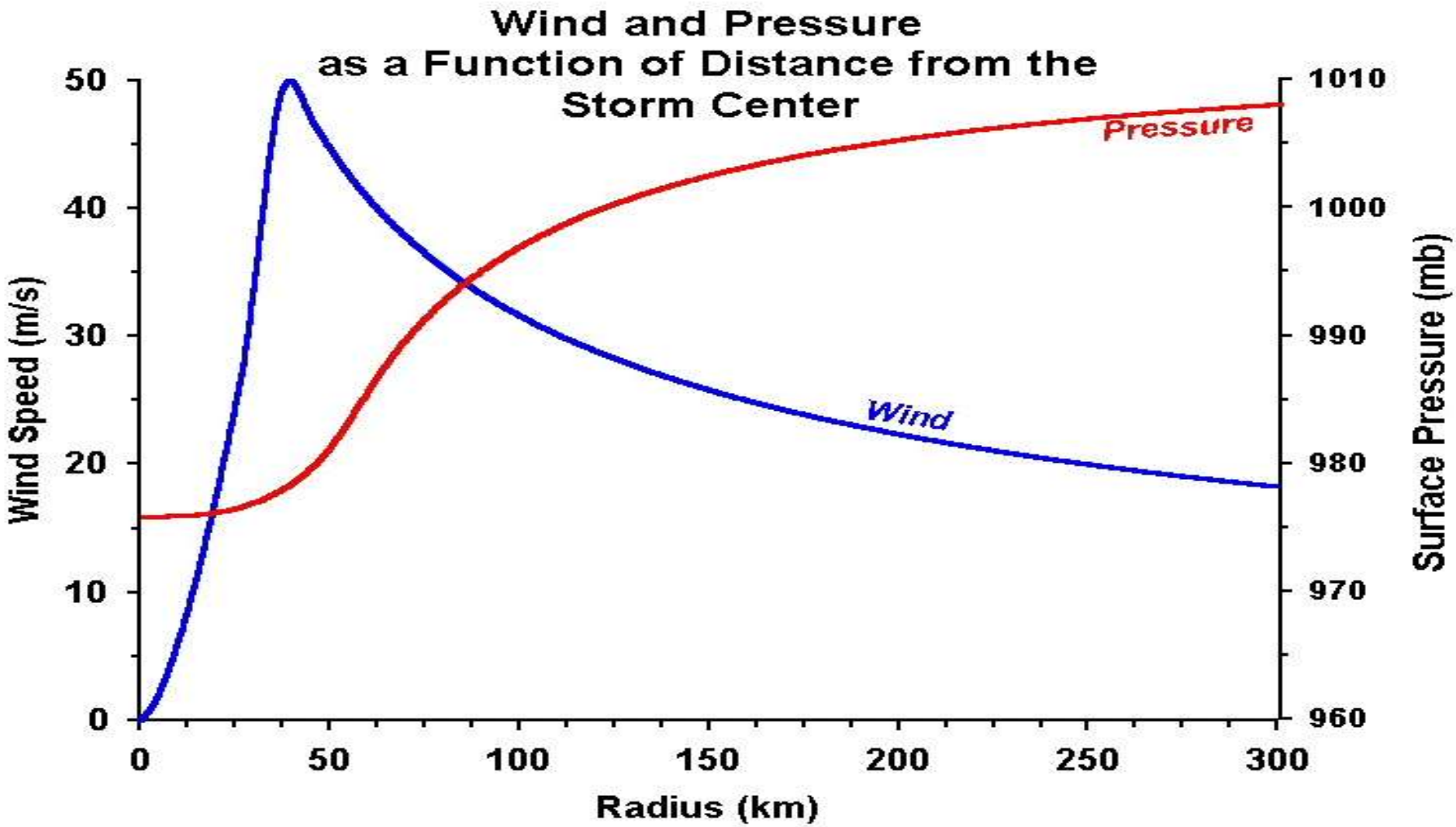
SAHARAN AIR LAYER



Schematic Hurricane Structure



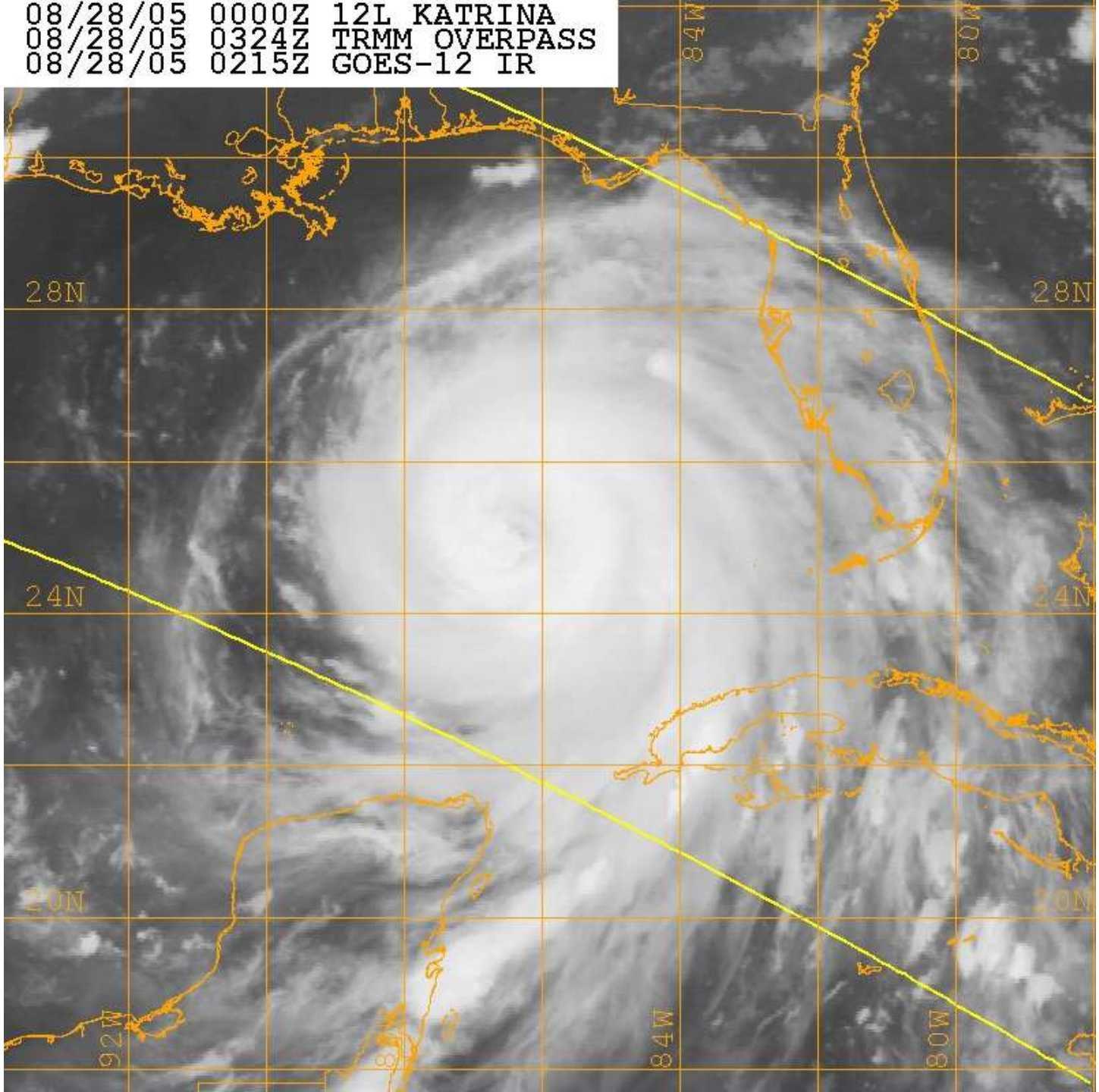
Hurricane Research Division
AOML/NOAA

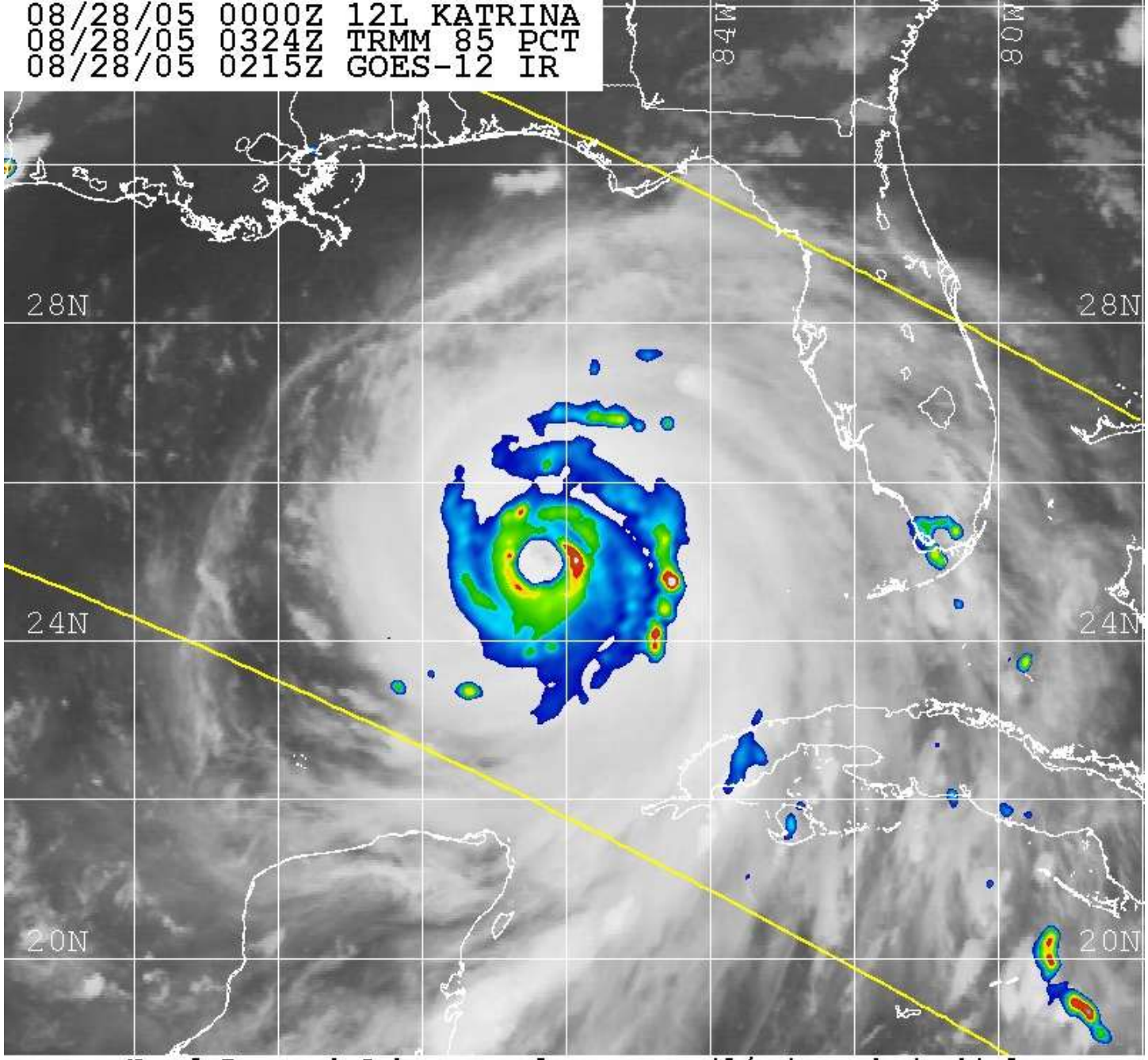

Wind and Pressure
as a Function of Distance from the
Storm Center
Pressure
Wind
Wind Speed (m/s)
Surface Pressure (mb)
Radius (km)
0
10
20
30
40
50
960
970
980
990
1000
1010
0
50
100
150
200
250
300

Hurricane Floyd
September 14, 1999 @ 1244 UTC

Hurricane Andrew
August 23, 1992 @ 1231 UTC

08/28/05 0000Z 12L KATRINA
08/28/05 0324Z TRMM OVERPASS
08/28/05 0215Z GOES-12 IR





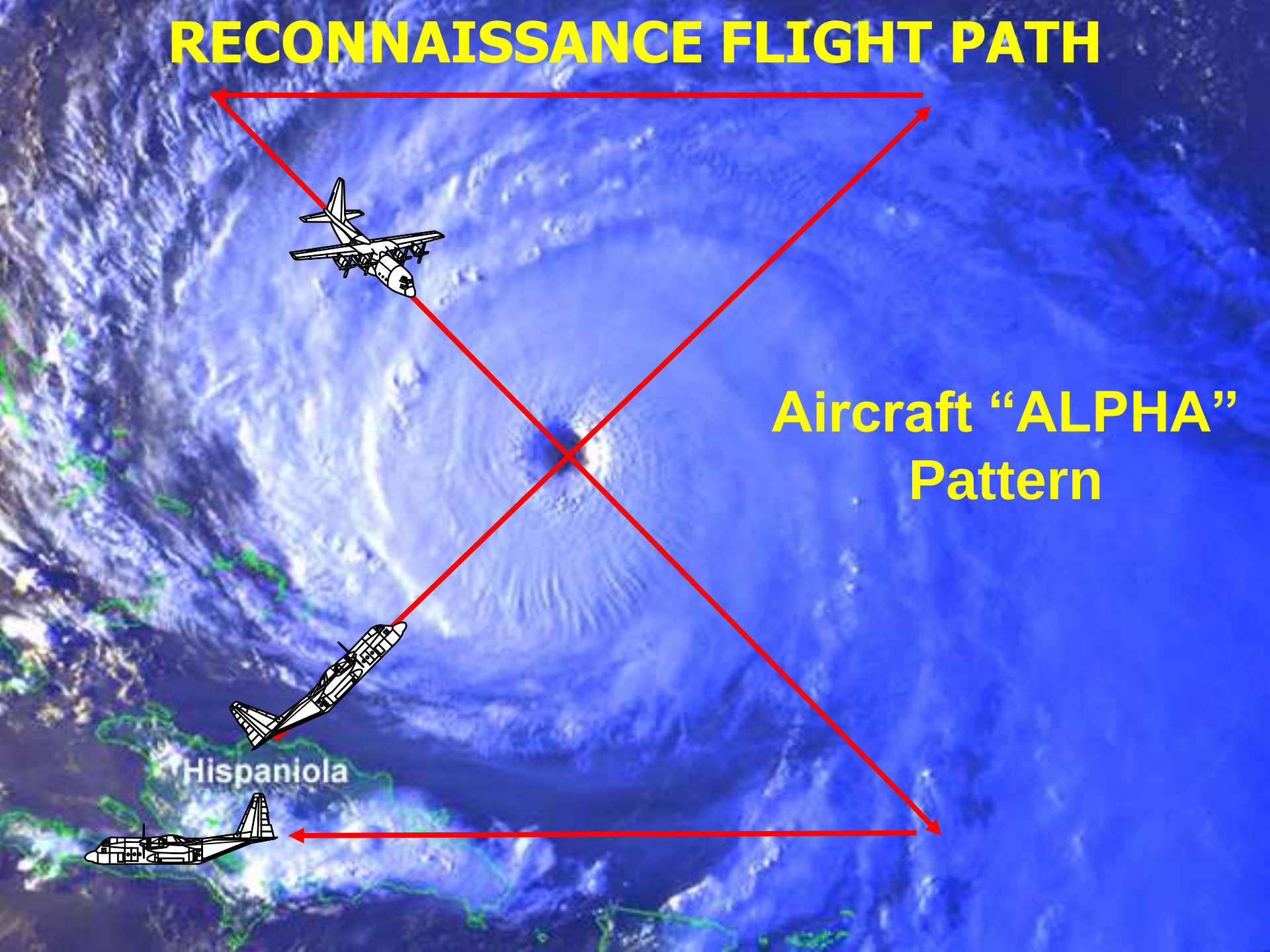
Naval Research Lab www.nrlmry.navy.mil/sat_products.html

<-- 85 GHz PCT (Kelvin) -->

170 180 190 200 210 220 230 240 250

HURRICANE HUNTERS-NOAA

RECONNAISSANCE FLIGHT PATH



Aircraft "ALPHA" Pattern

Numerical Models

Computer simulations of the atmosphere.

Computer solutions of fluid dynamics equations, equation of state, cumulus parameterizations and air-sea interactions.

Computers ingest observations, perform calculations and provide forecast data.

FLAVORS:

GLOBAL, REGIONAL, INTENSITY

$$\frac{du}{dt} = fv - \frac{1}{\rho}\frac{\partial p}{\partial x} + F_x \qquad p = \rho \mathrm{R_d} T \qquad \frac{\partial p}{\partial z} = -\rho g$$

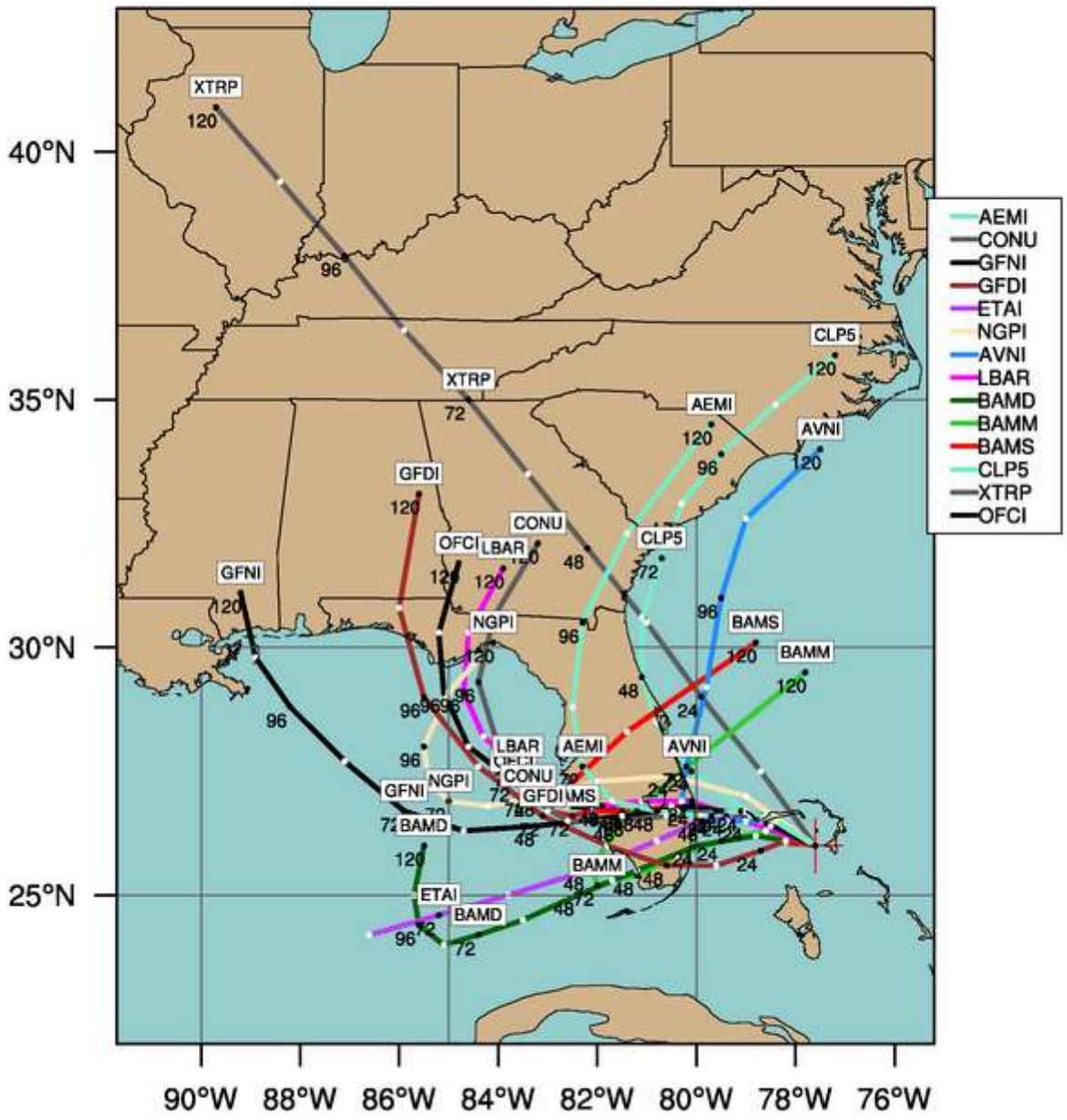
$$\frac{dv}{dt} = -fu - \frac{1}{\rho}\frac{\partial p}{\partial y} + F_y \qquad \theta = T\left(\frac{1000\mathrm{mb}}{\mathrm{p}}\right)^{Rd/cp}$$

$$\frac{dw}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial z} - fu\cot\theta - g + F_z \qquad \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \omega}{\partial p} = 0$$

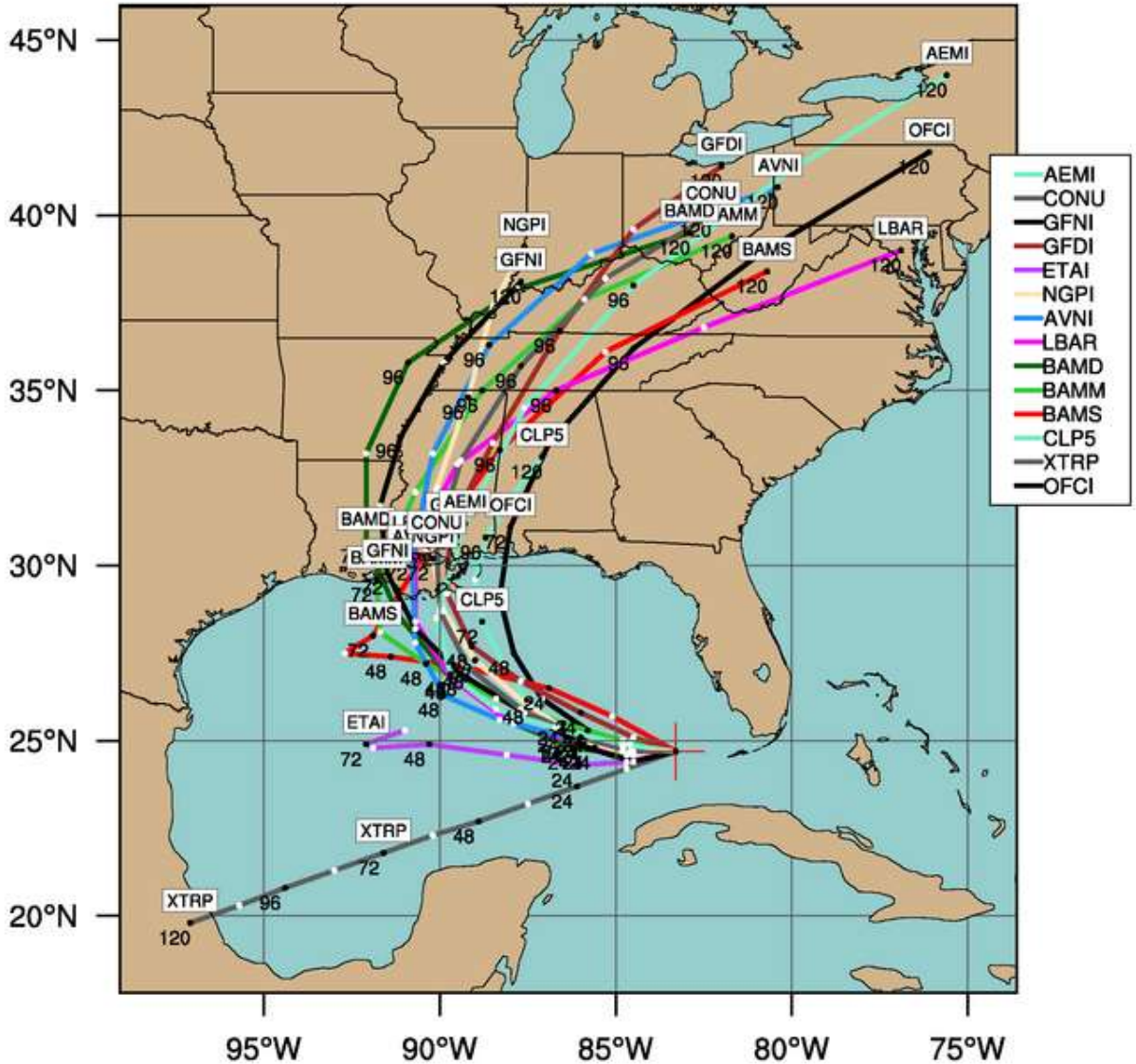
$$\frac{\partial \zeta}{\partial t} = -V \cdot \nabla(\zeta - \beta v) - (f + \zeta)\nabla \cdot V \qquad dh = c_p dT - \frac{1}{\rho} dp$$

$$\left(\nabla^2 + \frac{f_0^2 \partial^2}{\sigma \partial p^2}\right)\omega = \frac{f_0}{\sigma}\frac{\partial}{\partial p}\left[\vec{V}_g \cdot \nabla\left(\nabla^2 \Phi + f\right)\right] + \frac{1}{\sigma}\nabla^2\left[\vec{V}_g \cdot \nabla\left(-\frac{\partial \Phi}{\partial p}\right)\right]$$

Early-cycle track guidance valid 0000 UTC, 25 August 2005

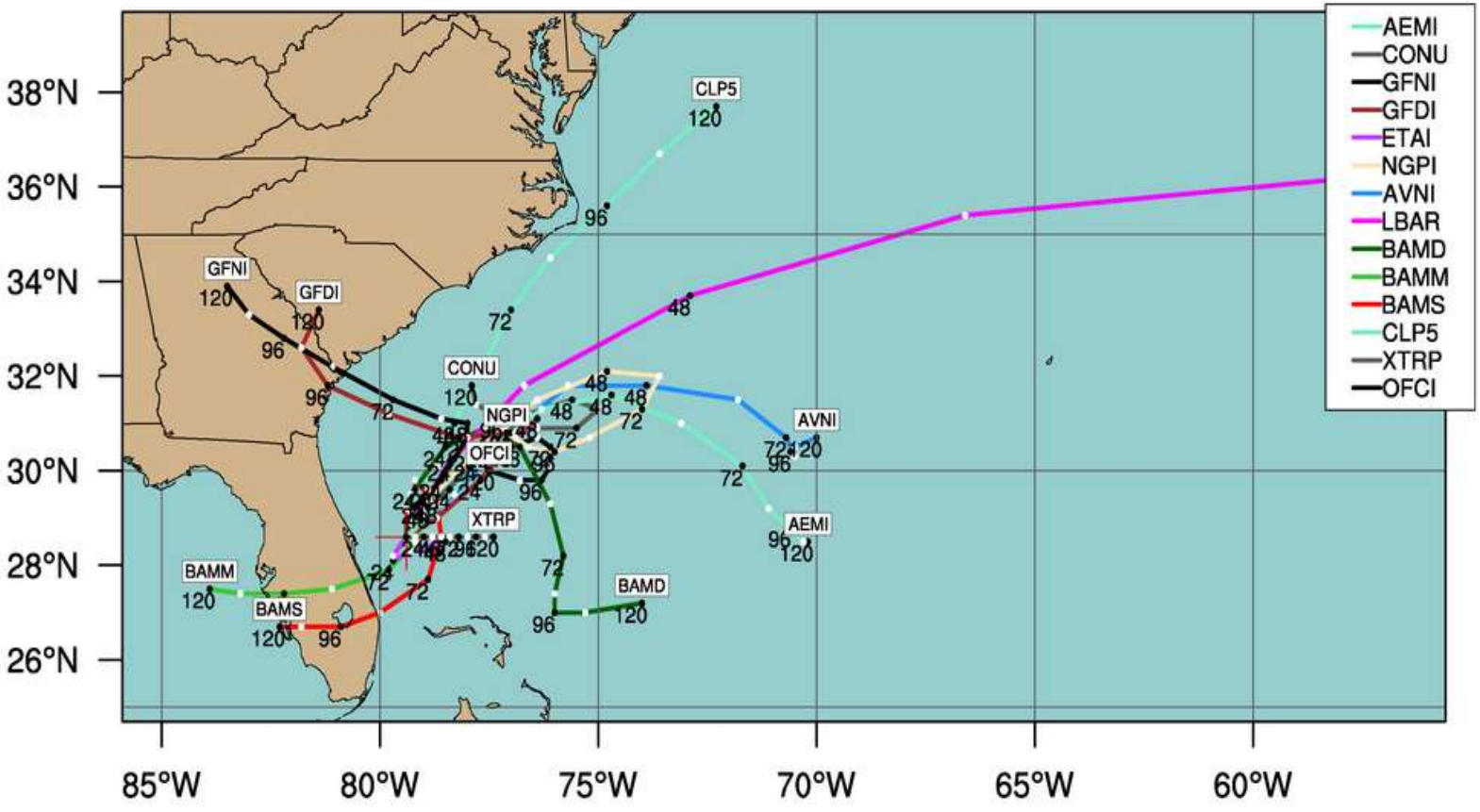


Early-cycle track guidance valid 0000 UTC, 27 August 2005

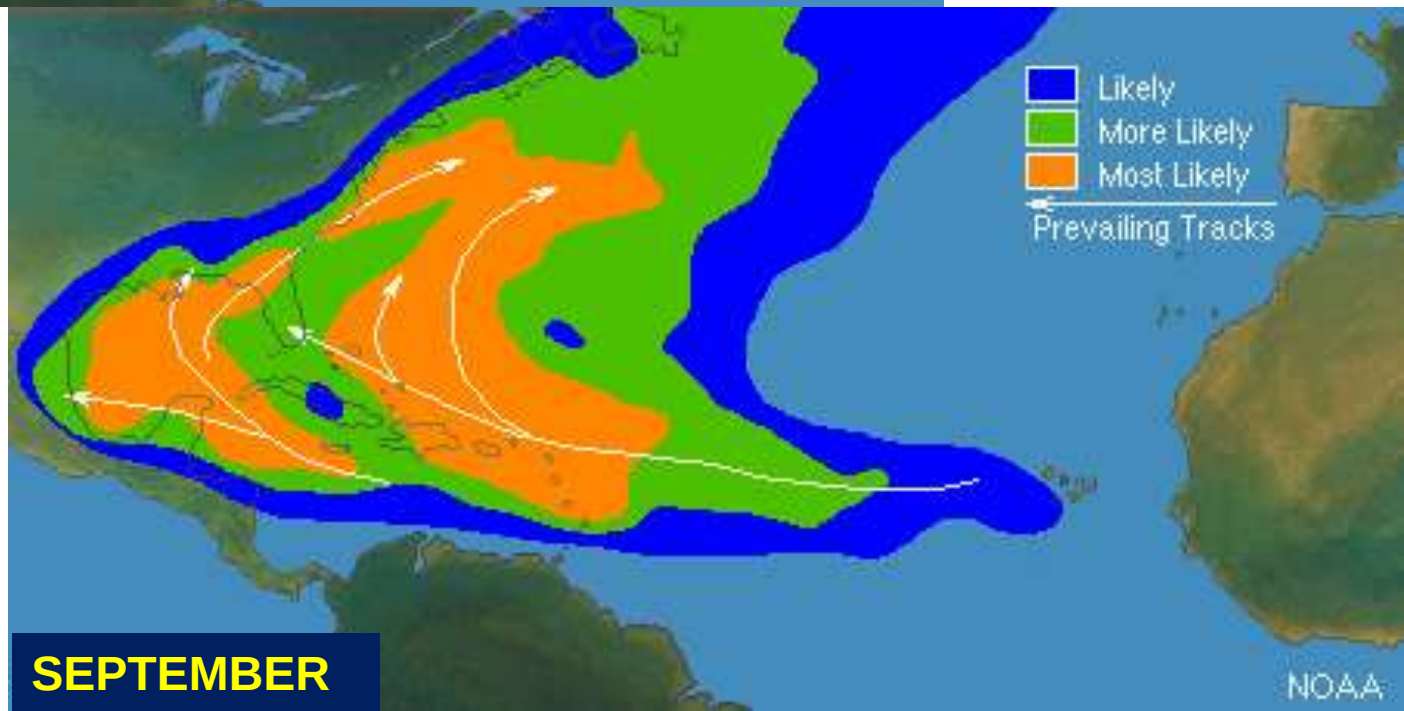


HURRICANE OPHELIA 2005

Early-cycle track guidance valid 0000 UTC, 09 September 2005



Likely
More Likely
Most Likely
Prevailing Tracks
JUNE
NOAA


Likely
More Likely
Most Likely
Prevailing Tracks
SEPTEMBER
NOAA

Questions?