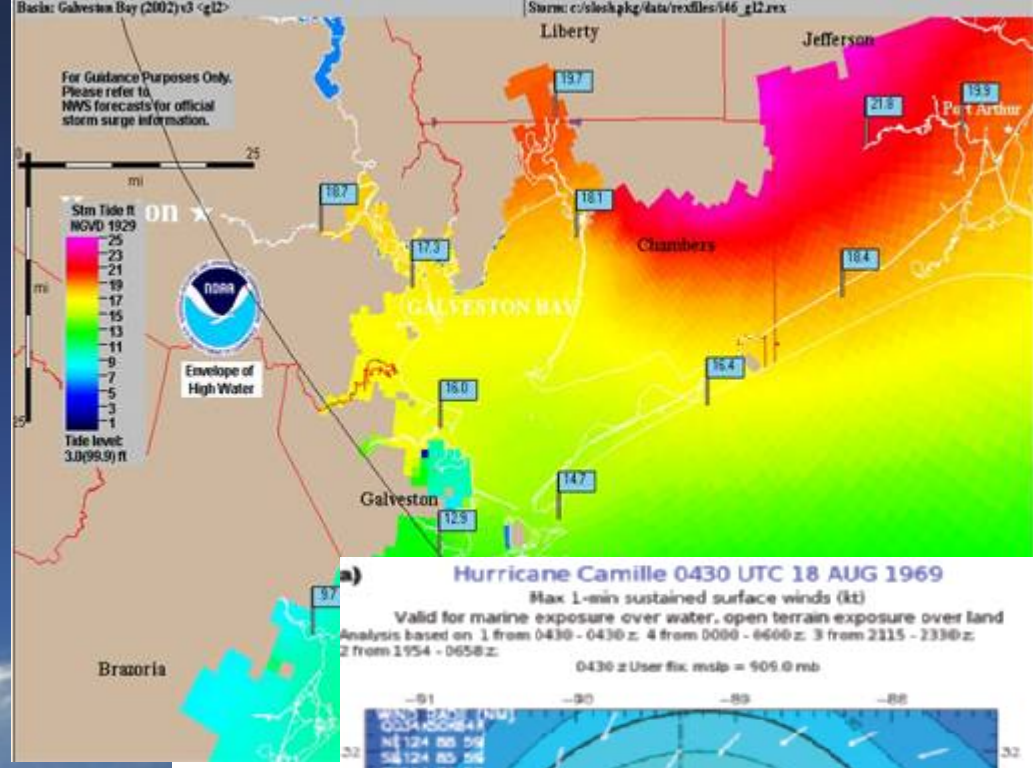
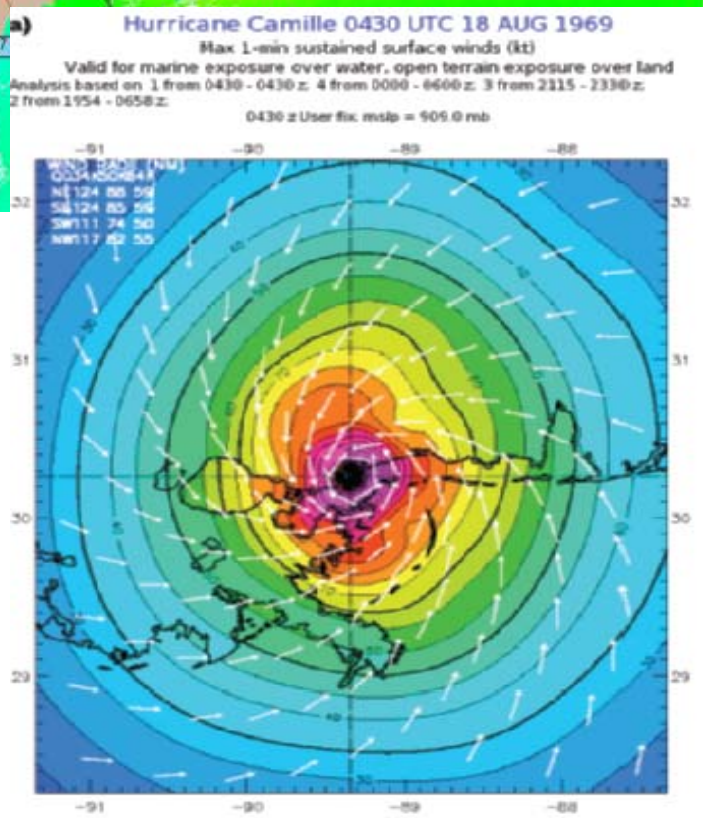
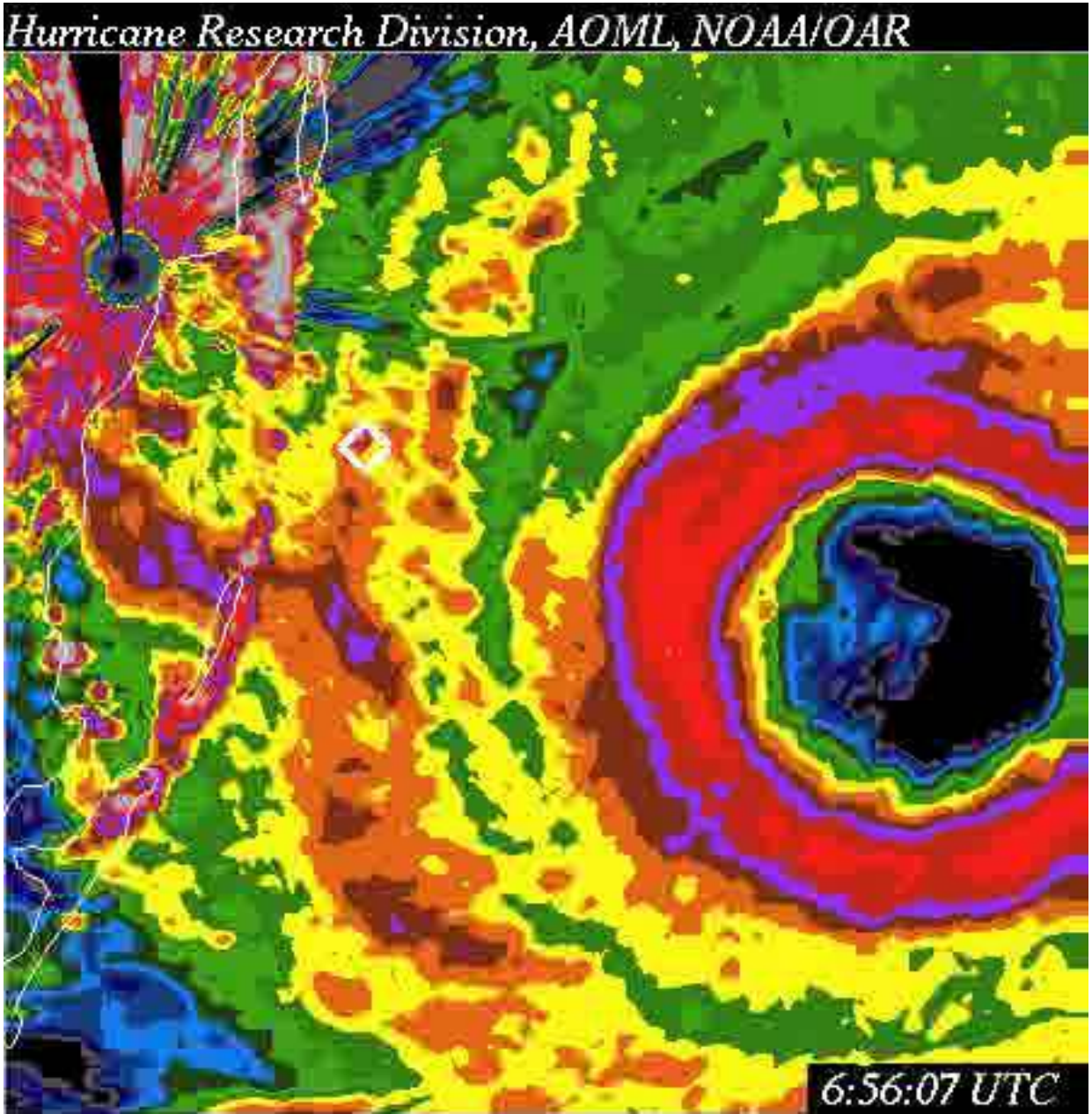
Hurricane Size versus Intensity and Implications Regarding Impact

Lt Colonel Richard G. Henning
USAF Reserve (Retired)
Consulting Meteorologist

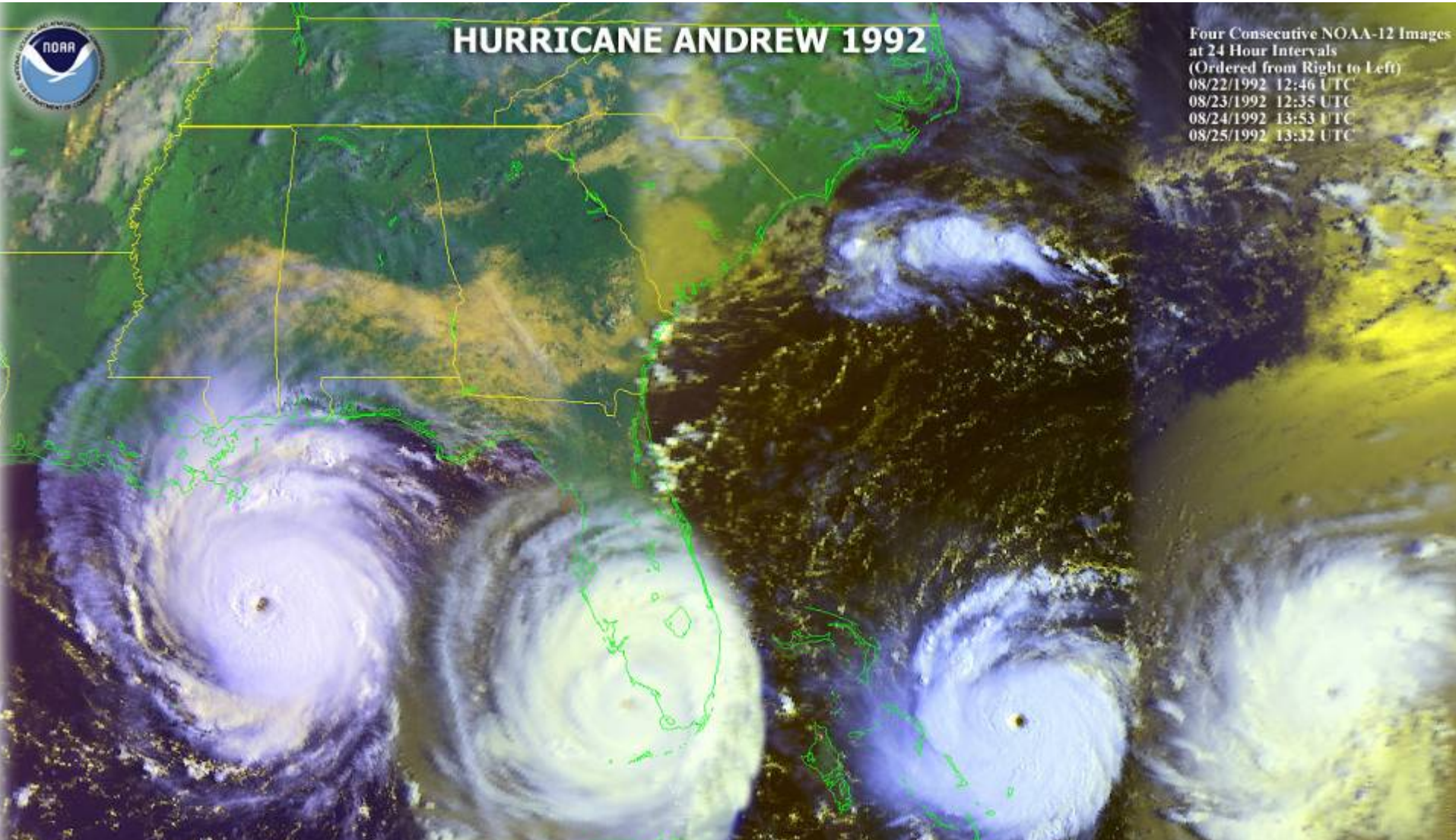




Hurricane Andrew (Dade County 1992):

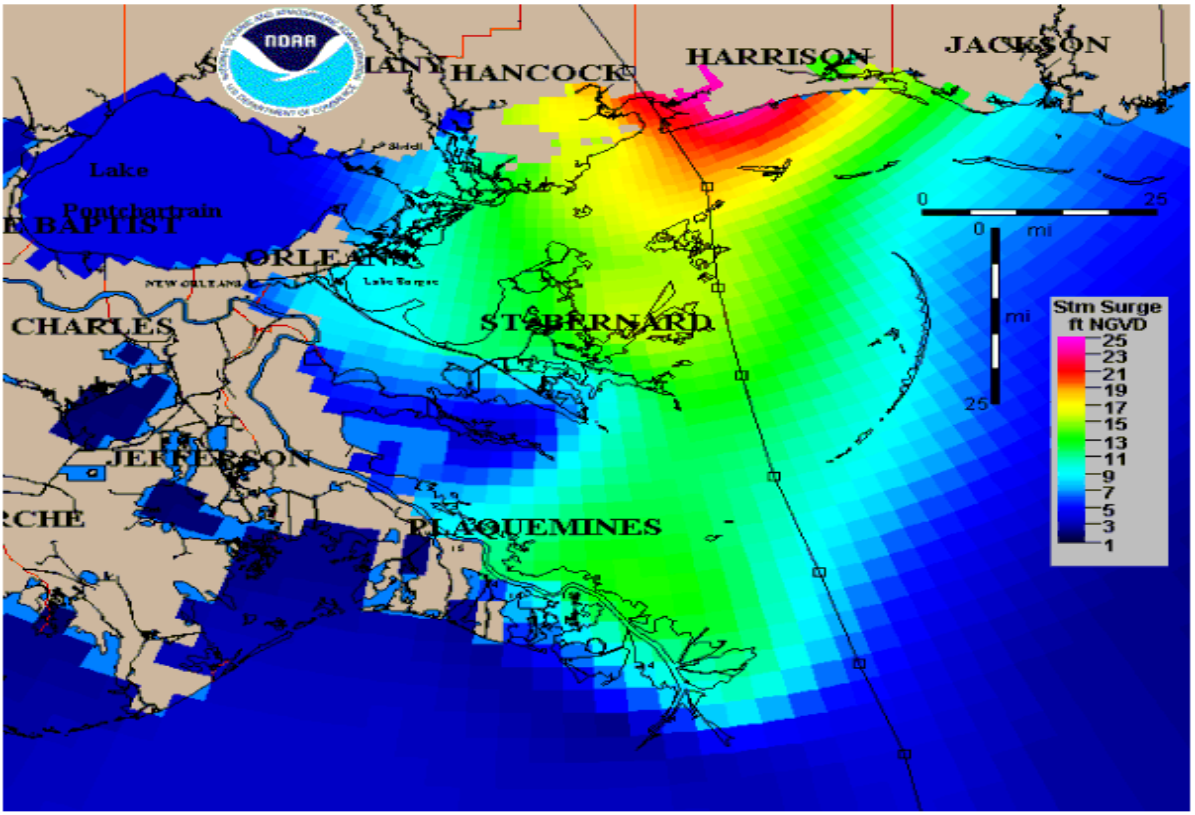


The Evolution of Hurricane Andrew from a Small, but Very Intense, Atlantic Hurricane Impacting Dade County, FL into a Larger, but Less Intense, Gulf Hurricane with Landfall in LA

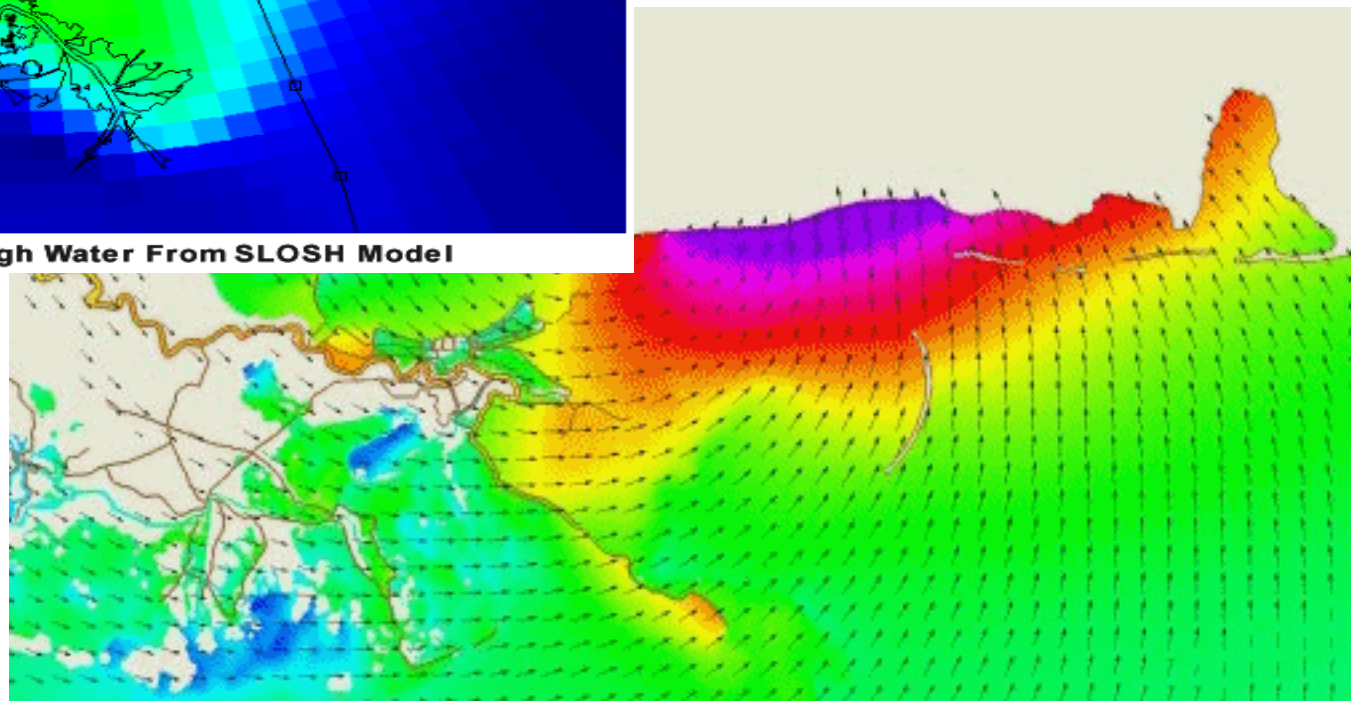


Camille's Surge versus Katrina's

(Wilson Shaffer, National Weather Service/NOAA)



Camille's Envelope of High Water From SLOSH Model

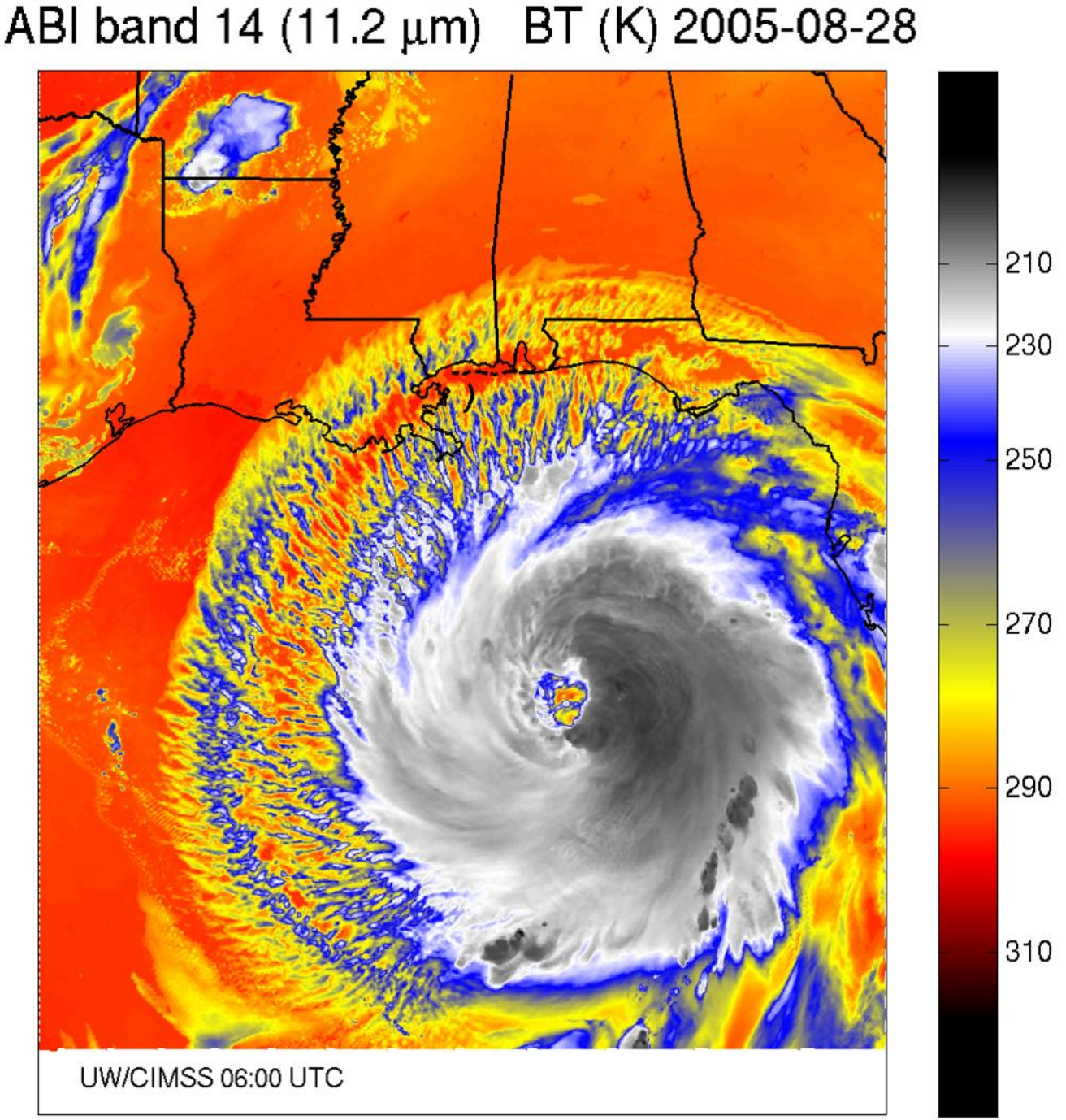


The Ability of a Tropical Cyclone to Generate Waves and Storm Surge Depends Upon:

- **Envelope of maximum winds, hurricane force winds and tropical storm force winds**
- **Fetch of the winds blowing across the ocean surface (length/orientation of wind vector and duration)**
- **Bathymetry (depth and shape) of the sea floor**
- **These parameters are not well captured at all using the Saffir Simpson Scale**
- **Some form of Dr. Powell's (NOAA HRD) Integrated Kinetic Energy (IKE) method of characterizing total storm energy capacity may be needed to better express potential for coastal destructive impact**

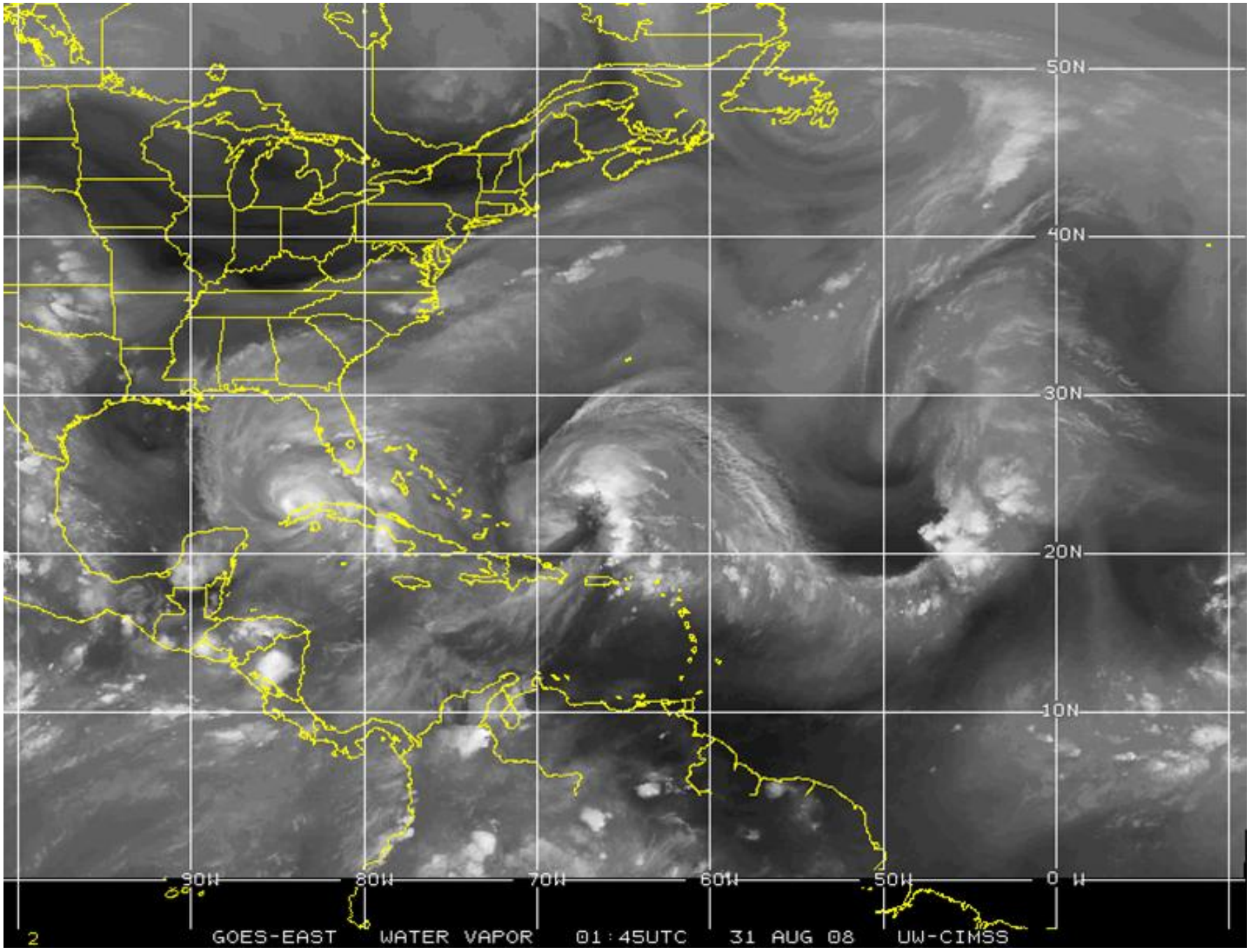
- **Small but intense, tightly structured, hurricanes (with very small eyes surrounded by a single, very intense eyewall containing a single powerful wind field maximum) are inherently unstable. They tend to be short-lived phenomena, evolving through internal mechanisms into core regions characterized by multiple eyewalls, much larger eyes, and greatly expanded wind fields.**
  - **Passage over land tends to hasten the breakdown of the single, tightly structured core into a broader center (ie: Gustav over western Cuba, Ike over eastern Cuba, Andrew over the FL Everglades in 1992)**
  - **Passage over land, however, is not necessary for such a change to occur (ie: Wilma changed greatly over the Northwest Caribbean prior to landfall over the Yucatan Peninsula, Katrina's wind field weakened in intensity but expanded greatly in size over the open waters of the northern Gulf well before landfall, Rita developed multiple eyewalls over the center of the Gulf)**
  - **While such transformation is nearly inevitable, it is not certain to occur (ie: Camille in 1969 maintained a very small core structure across the entire Gulf)**

Katrina Near Maximum Intensity as a Category 5 Storm on 28 August 2005

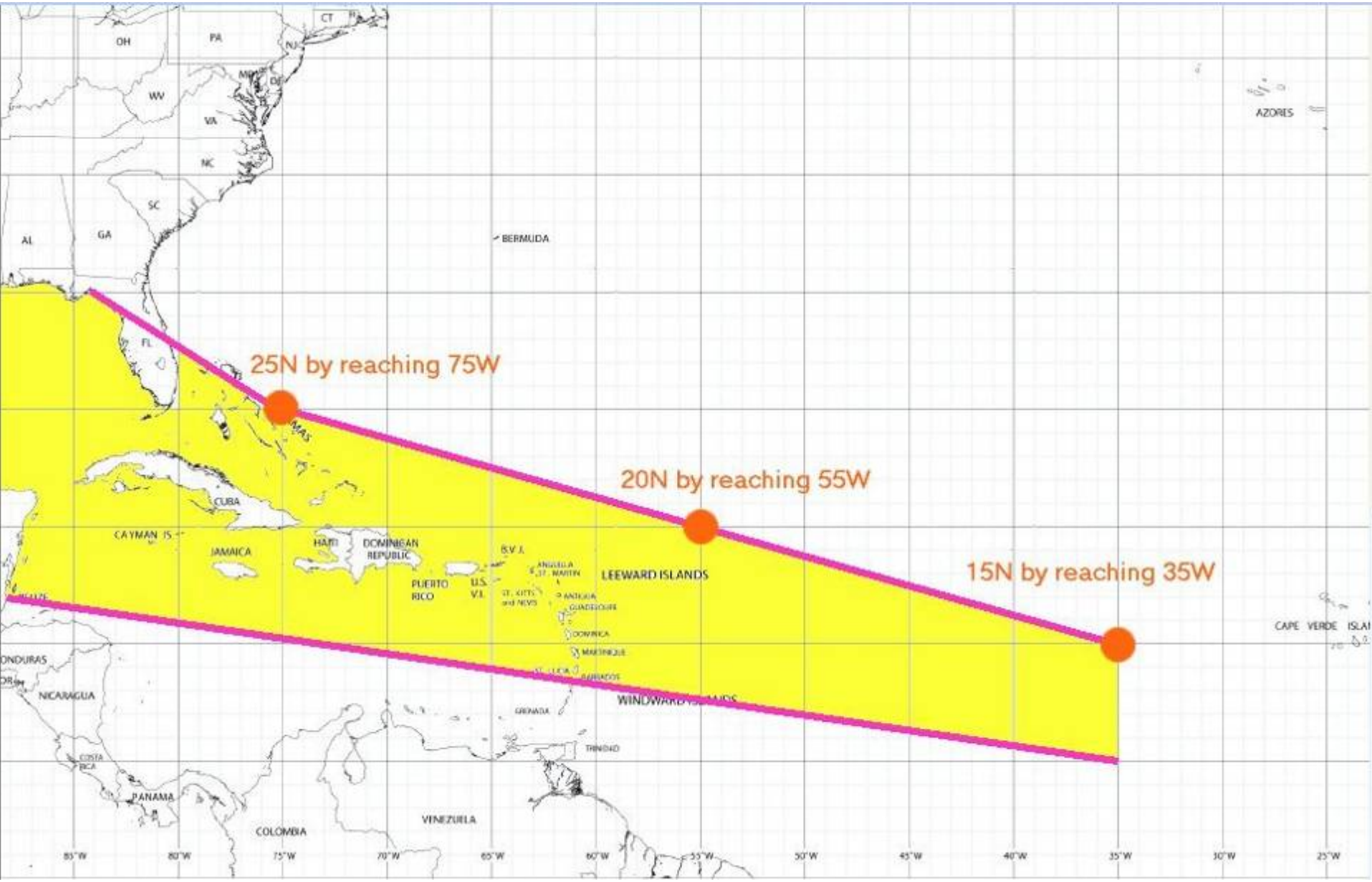


University of Wisconsin CIMSS Katrina Imagery Loop from Maximum Intensity to Landfall

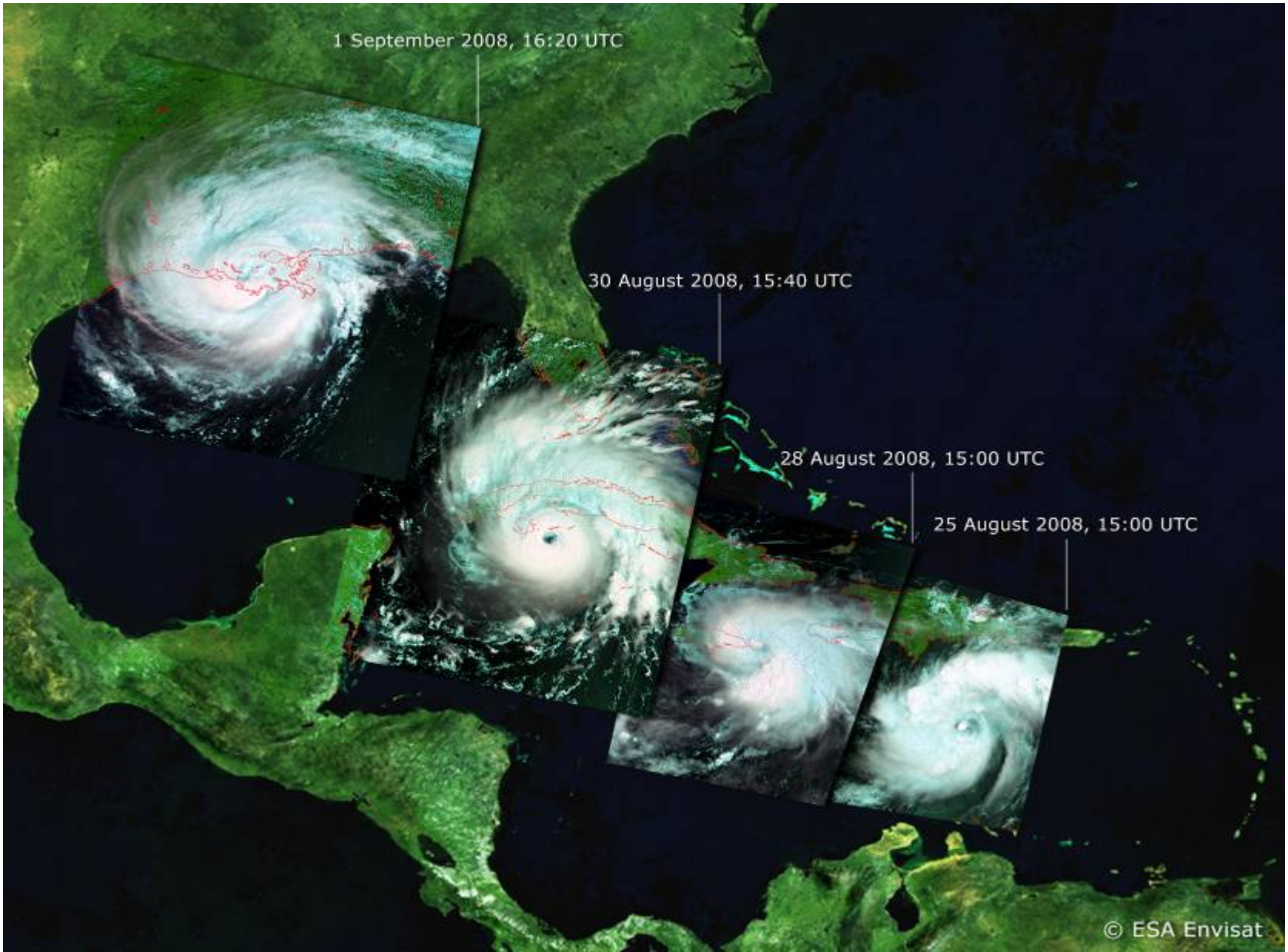
Life Cycles of Hurricanes Gustav and Ike in Late August–September 2008



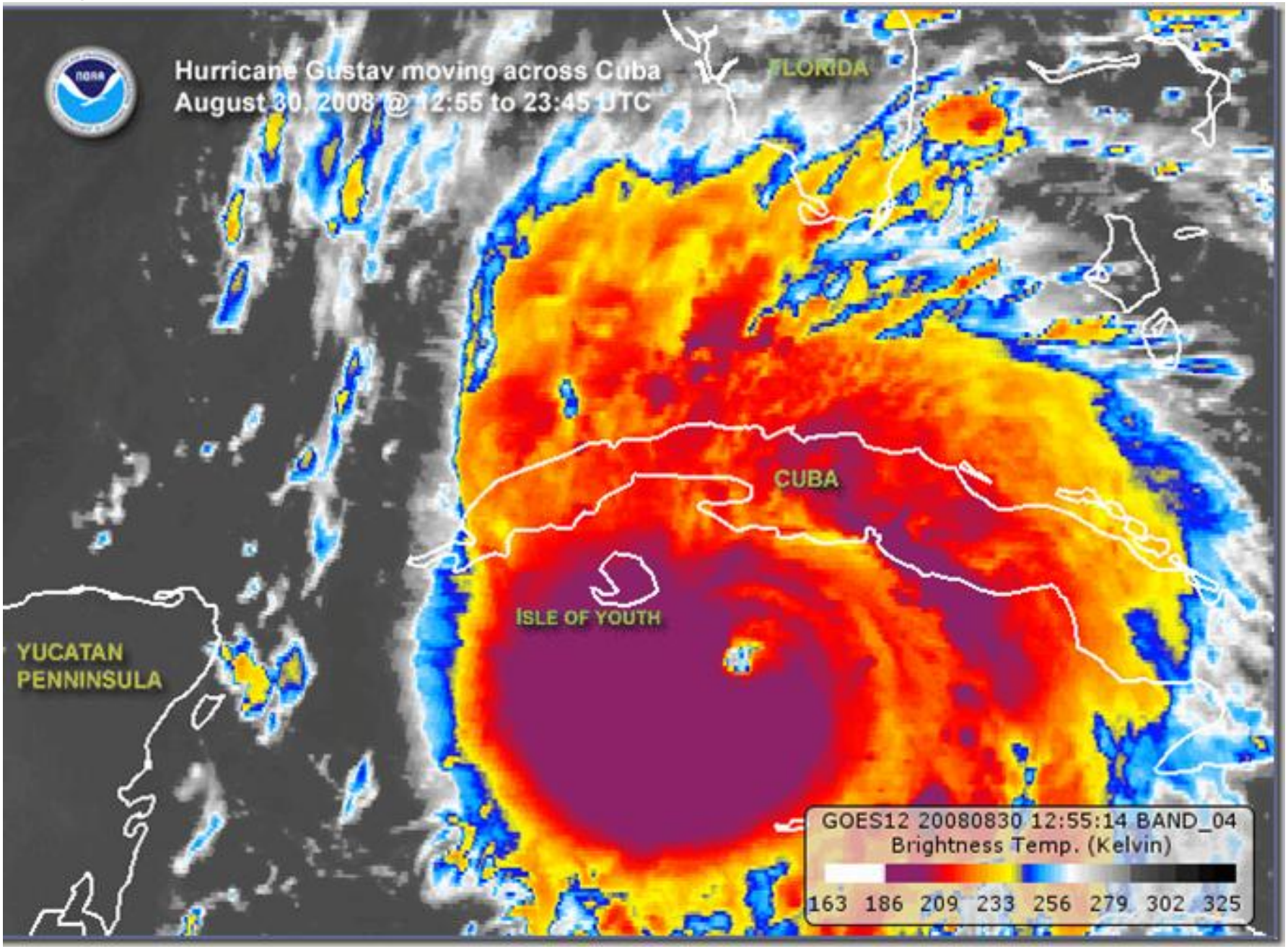
“35 – 55 – 75” Rule of Thumb for Cape Verde Storms



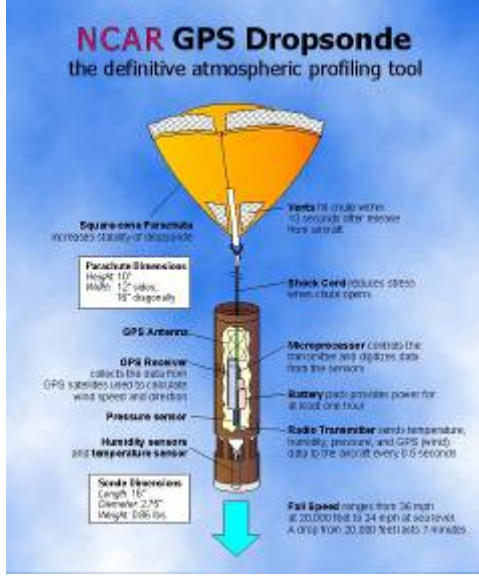
The Evolution of Hurricane Gustav from a Compact Cat 4 Caribbean Hurricane (Impacting Cuba) into a Much Larger, but Less Intense, Cat 2 Gulf Hurricane Making Landfall in South-central Louisiana



Compact Cat 4 Hurricane Gustav Makes Landfall over Western Cuba



Dropsonde released into Gustav during period of rapid intensification south of Cuban Coast:



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92318 23000 09135 85056 20602 12132 70721 12600 14138 88999 77999
31313 09608 81649
61616 AF308 1507A GUSTAV OB 05
62626 EYEWALL 045 SPL 2170N08226W 1653 MBL WND 08627 AEV 00000
DLM WND 11625 958701 WL150 07623 082 =
XXBB 80178 99216 70821 08112 00959 25205 11917 22400 22850 20602
33701 13200 44696 09600
21212 00959 07608 11950 08126 22944 07632 33941 07628 44937 08132
55933 08630 66926 09135 77915 09124 88911 09126 99903 09639 11893
10128 22887 10630 33880 11140 44875 11635 55869 11637 66850 12132
77696 14136
31313 09608 81649
61616 AF308 1507A GUSTAV OB 05
62626 EYEWALL 045 SPL 2170N08226W 1653 MBL WND 08627 AEV 00000 DL
M WND 11625 958701 WL150 07623 082 =

- **HURRICANE GUSTAV DISCUSSION NUMBER 25**
- **NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL072008**
- **500 PM EDT SAT AUG 30 2008**

- **....A FLIGHT-LEVEL WIND OF 143 KT**
- **AT 700 MB WAS JUST REPORTED IN THE NORTHEASTERN EYEWALL...WHICH**
- **SUPPORTS INCREASING THE ADVISORY INTENSITY TO 130 KT. MODEST**
- **ADDITIONAL STRENGTHENING DURING THE NEXT FEW HOURS COULD LEAD TO**
- **CATEGORY FIVE INTENSITY AS GUSTAV CROSSES WESTERN CUBA...BUT THE**
- **OFFICIAL FORECAST DOES NOT EXPLICITLY CALL FOR CATEGORY FIVE STATUS**
- **UNTIL 24 HOURS. AFTER DEPARTING CUBA...THE HURRICANE WILL PASS**
- **OVER THE WARM LOOP CURRENT IN THE SOUTHEASTERN GULF OF MEXICO...AND**
- **VERTICAL WIND SHEAR IS NOT FORECAST BY THE MODELS TO BECOME**
- **PROHIBITIVELY STRONG DURING THE NEXT COUPLE OF DAYS...SO THE**
- **OFFICIAL FORECAST MAINTAINS A MAJOR HURRICANE ALL THE WAY TO FINAL**
- **LANDFALL....**

- **...THE NHC WIND SPEED PROBABILITIES...INCLUDED IN THIS ADVISORY PACKAGE**
- **IN BOTH TEXT AND GRAPHICAL FORMATS...DEPICT A RELATIVELY SIMILAR**
- **RISK OF HURRICANE-FORCE WINDS AT INDIVIDUAL LOCATIONS ALONG A WIDE**
- **STRETCH OF THE NORTHERN GULF COAST...**

- **FORECAST POSITIONS AND MAX WINDS**
-
- **INITIAL 30/2100Z 22.1N 82.9W 130 KT**
- **12HR VT 31/0600Z 23.4N 84.4W 135 KT**
- **24HR VT 31/1800Z 25.3N 86.5W 140 KT**
- **36HR VT 01/0600Z 27.2N 88.6W 135 KT**
- **48HR VT 01/1800Z 29.0N 90.7W 125 KT**
- **72HR VT 02/1800Z 31.0N 93.0W 70 KT...INLAND**

- HURRICANE GUSTAV DISCUSSION NUMBER 26
- NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL072008
- 1100 PM EDT SAT AUG 30 2008

- THE EYE OF GUSTAV CROSSED WESTERN CUBA DURING THE PAST SEVERAL
- HOURS AND IS NOW OVER THE SOUTHEASTERN GULF OF MEXICO. THE
- HURRICANE WEAKENED DURING PASSAGE OVER LAND...WITH THE EYE BECOMING
- CLOUD FILLED AND THE EYEWALL CONVECTION BECOME LESS IMPRESSIVE IN
- BOTH SATELLITE AND RADAR DATA. IT IS ESTIMATED THAT THE INITIAL
- INTENSITY HAS DECREASED TO 120 KT....

- THE INTENSITY FORECAST REMAINS PROBLEMATIC. ANALYSES FROM CIMSS AT
- THE UNIVERSITY OF WISCONSIN SUGGEST THAT THE INTENSIFICATION
- OCCURRED DESPITE ABOUT 20 KT OF SOUTHERLY VERTICAL SHEAR CAUSED BY
- AN UPPER-LEVEL TROUGH OVER THE GULF OF MEXICO. THE PRESENCE OF
- THIS SHEAR IS SUPPORTED BY RADAR DATA FROM THE KEY WEST WSR-88D...
- WHICH CURRENTLY SHOWS A WEAK SOUTHERN EYEWALL AND LITTLE
- PRECIPITATION SOUTH OF THE EYEWALL. THE SHIPS MODEL SUGGESTS THE
- SHEAR SHOULD DIMINISH SOME DURING THE NEXT 18 HR...THEN INCREASE
- AGAIN AS GUSTAV MOVES BETWEEN THE TROUGH AND AN UPPER-LEVEL
- ANTICYCLONE TO THE SOUTHEAST. ON THE OCEAN SIDE...GUSTAV IS
- FORECAST TO PASS OVER THE LOOP CURRENT DURING THE NEXT 24 HOURS...
- THEN POSSIBLY PASS OVER A COUPLE OF COLD EDDIES NORTH OF 26N. ALL
- GUIDANCE FORECAST RE-INTENSIFICATION DURING THE NEXT 24 HR...SO THE
- INTENSITY FORECAST WILL CALL FOR A PEAK INTENSITY OF 135 KT IN 24
- HR...FOLLOWED BY SLIGHT WEAKENING BEFORE LANDFALL DUE TO SHEAR AND
- LOWER HEAT CONTENT...THEN FASTER WEAKENING OVER LAND. DUE TO THE
- VARIOUS FACTORS...THIS IS A LOW CONFIDENCE INTENSITY FORECAST.

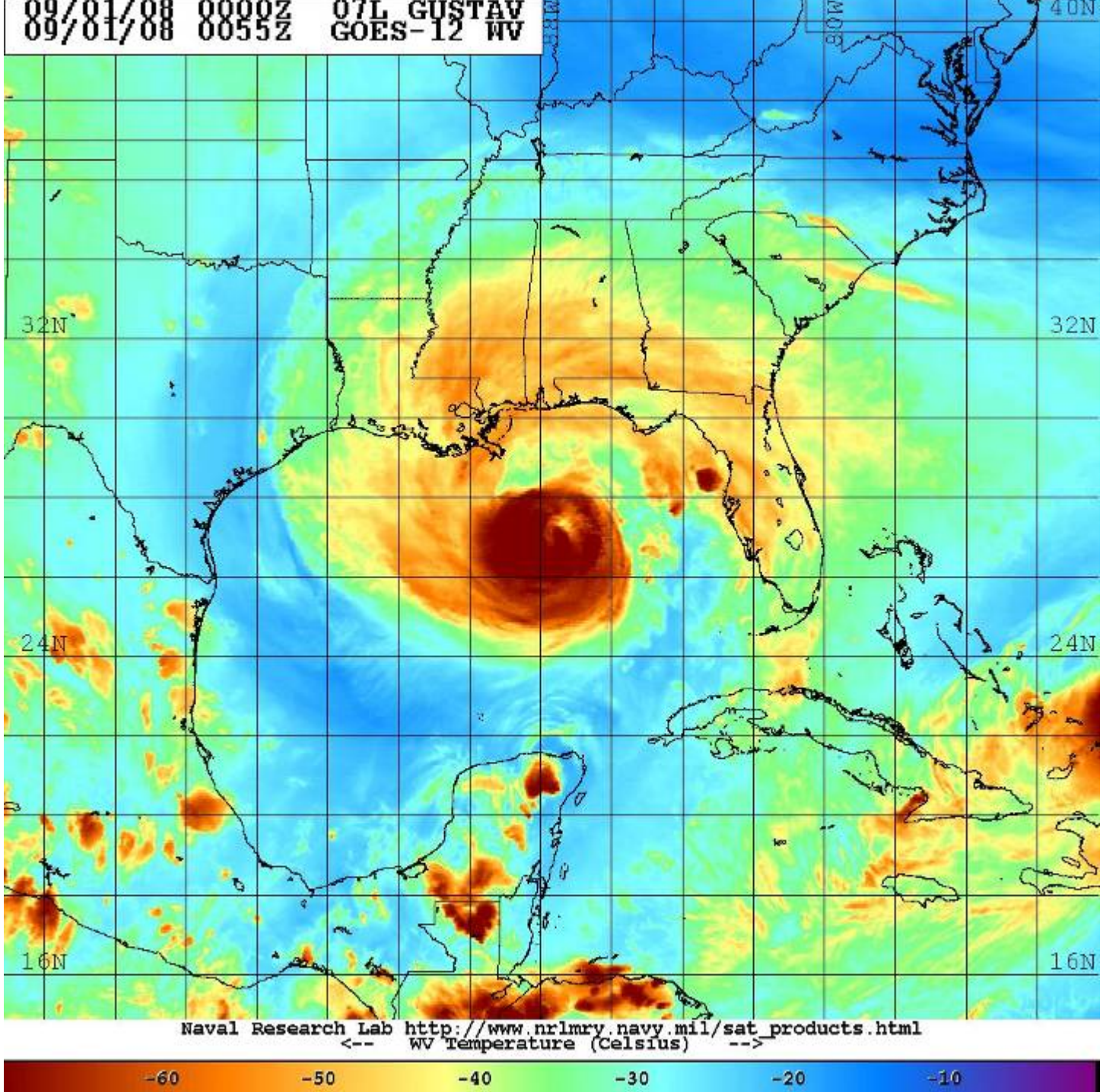
- FORECAST POSITIONS AND MAX WINDS
-
- INITIAL 31/0300Z 23.1N 83.8W 120 KT
- 12HR VT 31/1200Z 24.6N 85.3W 130 KT
- 24HR VT 01/0000Z 26.5N 87.4W 135 KT
- 36HR VT 01/1200Z 28.3N 89.5W 130 KT
- 48HR VT 02/0000Z 29.8N 91.2W 120 KT...INLAND
- 72HR VT 03/0000Z 31.5N 93.0W 50 KT...INLAND

- **HURRICANE GUSTAV DISCUSSION NUMBER 27**
- **NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL072008**
- **500 AM EDT SUN AUG 31 2008**

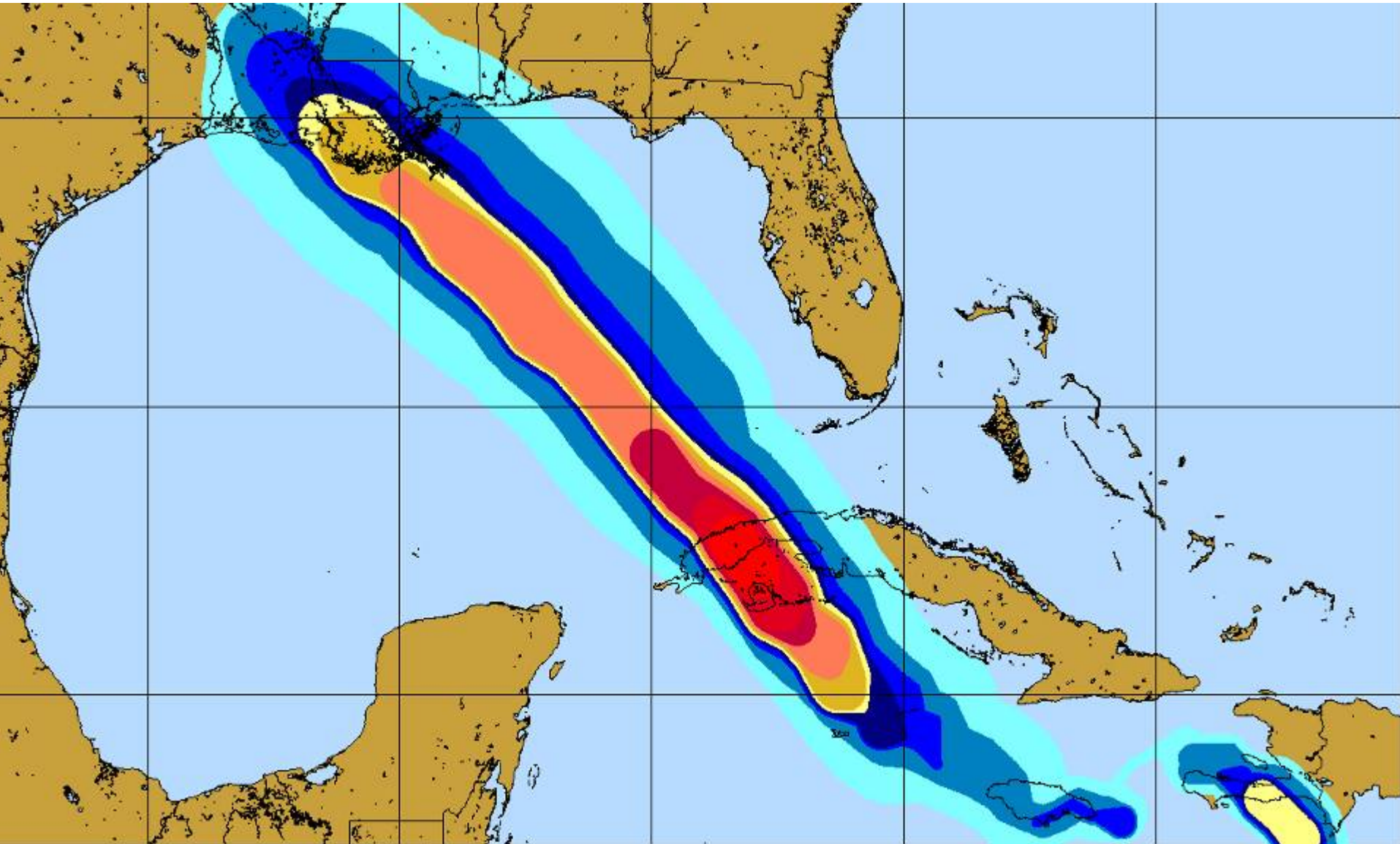
- **APPARENTLY...THE INTERACTION WITH WESTERN CUBA TOOK MORE OF A TOLL**
- **ON THE HURRICANE THAN EARLIER ESTIMATED. DATA FROM THE AIR FORCE**
- **HURRICANE HUNTER SHOW THAT GUSTAV HAS WEAKENED WITH MAXIMUM**
- **FLIGHT-LEVEL WINDS OF 112 KT...SFMR WINDS OF 98 KT...AND A MINIMUM**
- **CENTRAL PRESSURE OF 958 MB. SATELLITE IMAGES CONFIRM THIS WEAKENING**
- **TREND AS THE EYE NO LONGER VISIBLE. AIRCRAFT AND RADAR OBSERVATIONS**
- **ALSO INDICATE THAT THE EYE HAS EXPANDED TO AROUND 25 N MI IN**
- **DIAMETER. THE INITIAL INTENSITY IS LOWERED TO 110 KT...AND GUSTAV**
- **MAY EVEN BE A LITTLE WEAKER FOR THE MOMENT. HOWEVER THIS WEAKENING**
- **IS FORECAST TO BE SHORT-LIVED AS THE HURRICANE TRAVERSES THE**
- **RELATIVELY HIGH HEAT CONTENT OF THE GULF LOOP CURRENT. BEYOND 24**
- **HOURS...THE HEAT CONTENT DECREASES AND MOST MODELS INCREASE THE**
- **VERTICAL WIND SHEAR NEAR GUSTAV DUE TO AN UPPER-LEVEL LOW OVER THE**
- **WESTERN GULF. IN ADDITION...NONE OF THE NUMERICAL GUIDANCE SHOW**
- **SIGNIFICANT RESTRENGTHENING OF GUSTAV...ALTHOUGH ADMITTEDLY THE**
- **SKILL OF THESE MODELS IS RATHER LOW. THE OFFICIAL INTENSITY**
- **FORECAST IS REDUCED FROM THE EARLIER ONE...BUT STILL SHOWS GUSTAV**
- **AS A MAJOR HURRICANE AT LANDFALL.**

- **....IT IS IMPORTANT NOT TO FOCUS**
- **ON THE EXACT TRACK OF GUSTAV AS THIS IS A LARGE HURRICANE AND**
- **SIGNIFICANT IMPACTS ARE LIKELY TO OCCUR WELL AWAY FROM THE CENTER.**

- **FORECAST POSITIONS AND MAX WINDS**
-
- **INITIAL 31/0900Z 24.2N 85.0W 110 KT**
- **12HR VT 31/1800Z 25.6N 86.3W 120 KT**
- **24HR VT 01/0600Z 27.5N 88.4W 125 KT**
- **36HR VT 01/1800Z 29.1N 90.4W 115 KT...NEAR COAST**
- **48HR VT 02/0600Z 30.5N 92.2W 75 KT...INLAND**

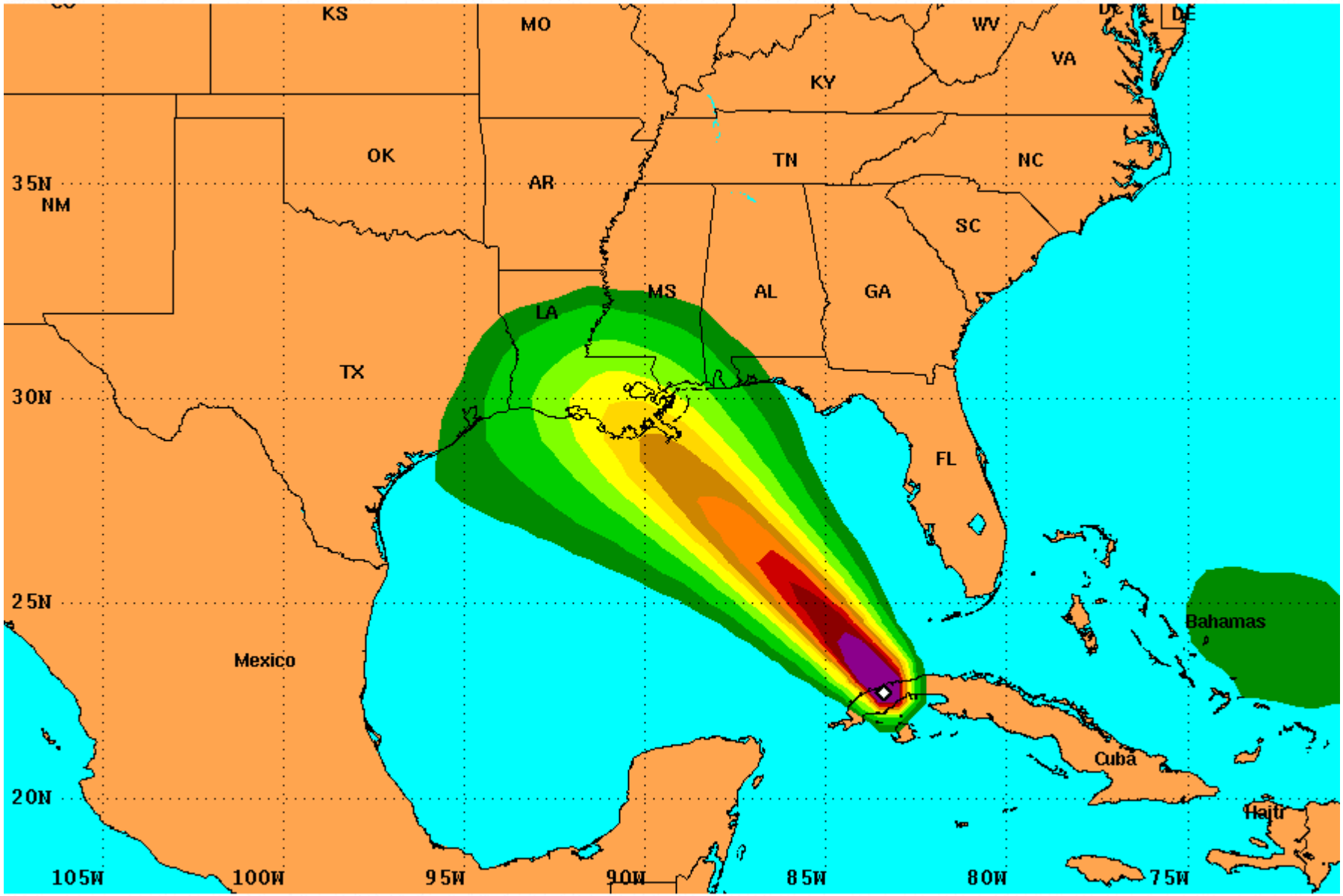

09/01/08 0000Z 07L GUSTAV
09/01/08 0855Z GOES-12 WV
40N
32N
24N
16N
80W
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- WV Temperature (Celsius) -->
-60
-50
-40
-30
-20
-10

Wind Swath of Gustav



Hurricane Force Wind Speed Probabilities

For the 120 hours (5 days) from 8 PM EDT Sat Aug 30 to 8 PM EDT Thu Sep 4

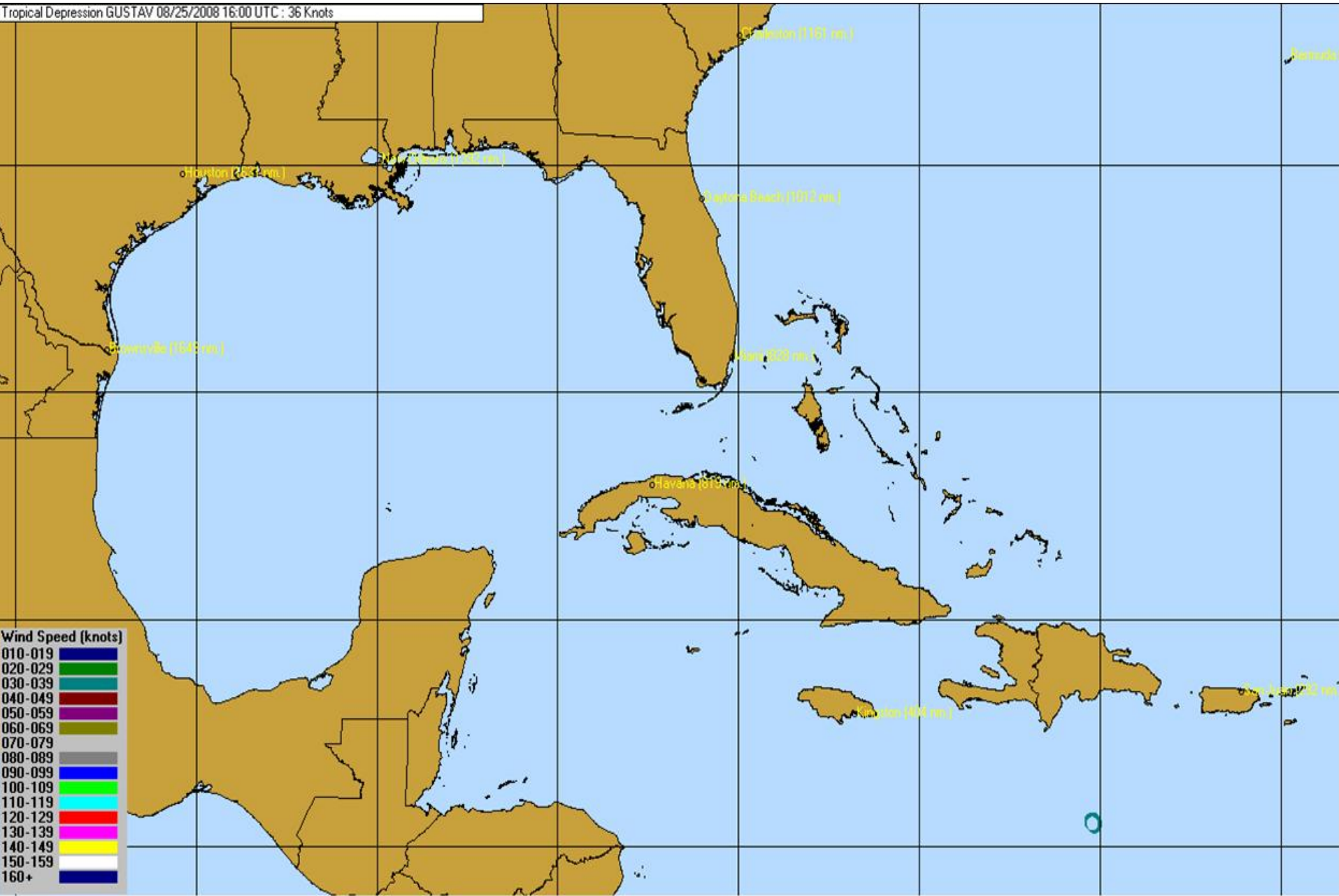


Probability of hurricane force surface winds (1-minute average >= 74 mph) from all tropical cyclones

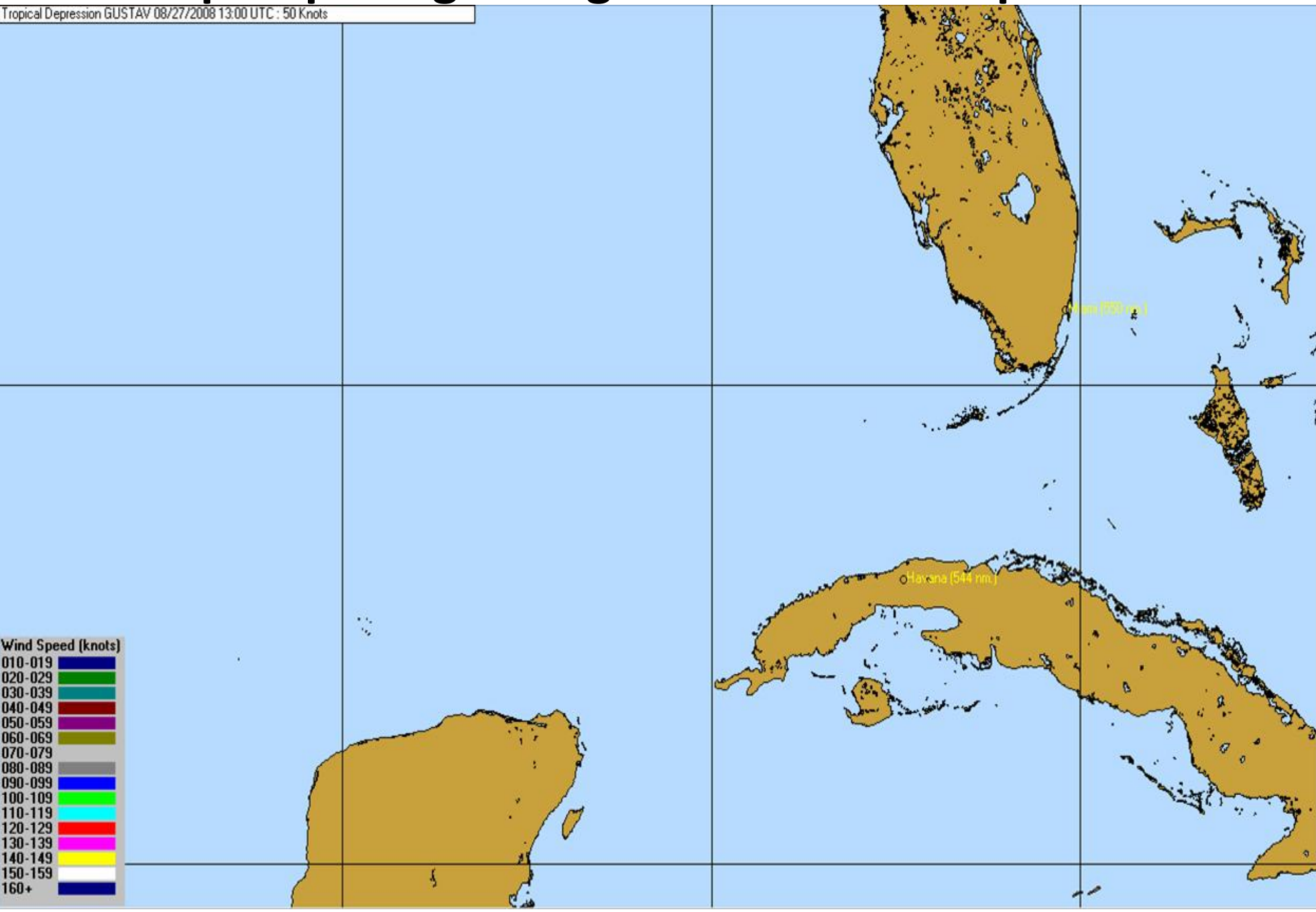
◇ indicates HURRICANE GUSTAV center location at 8 PM EDT Sat Aug 30 2008 (Forecast/Advisory #26)

5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Wind Envelope History of Hurricane Gustav



Close-up Depicting Change in Wind Envelope of Gustav

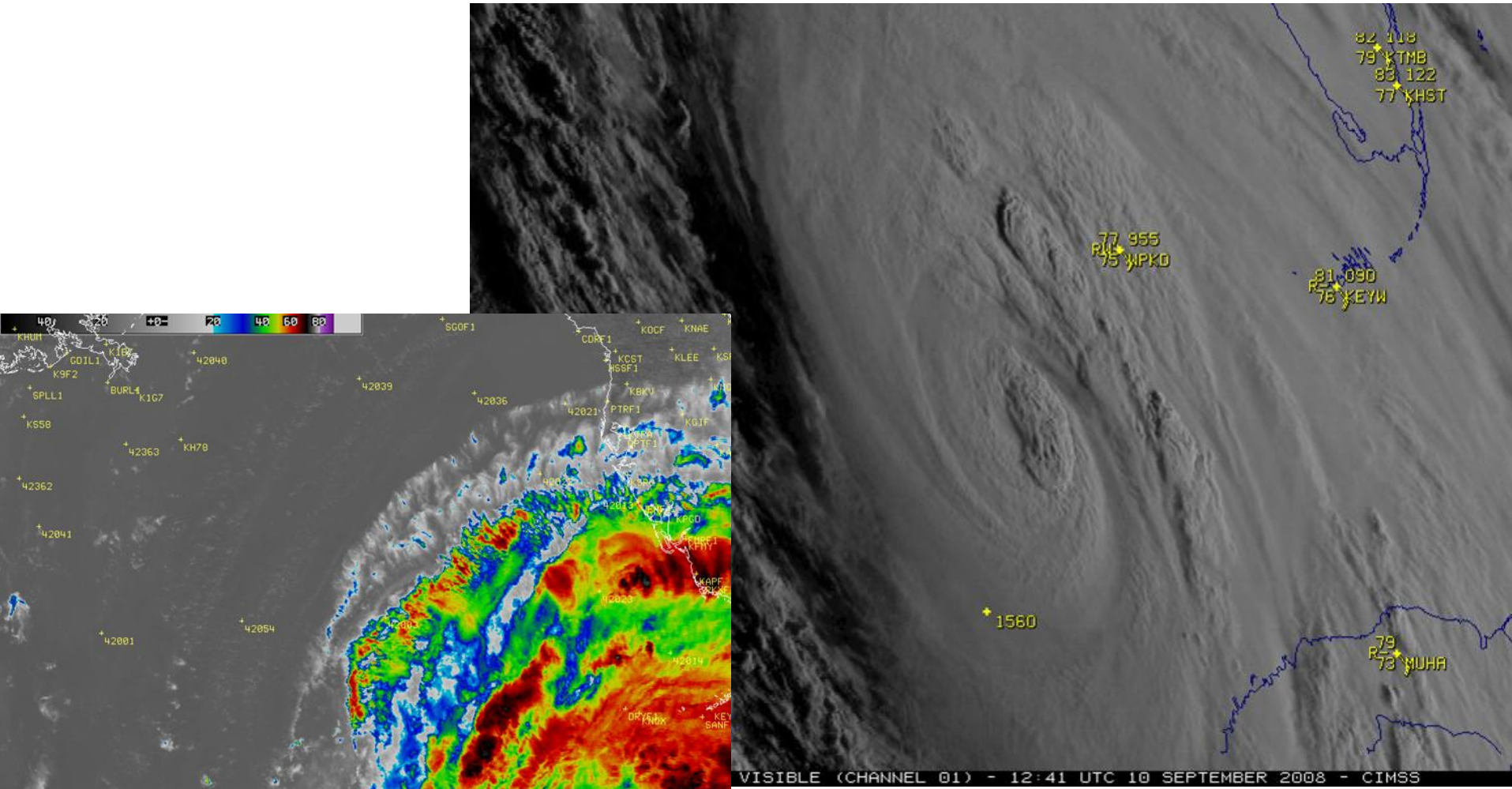


Ike in the Gulf

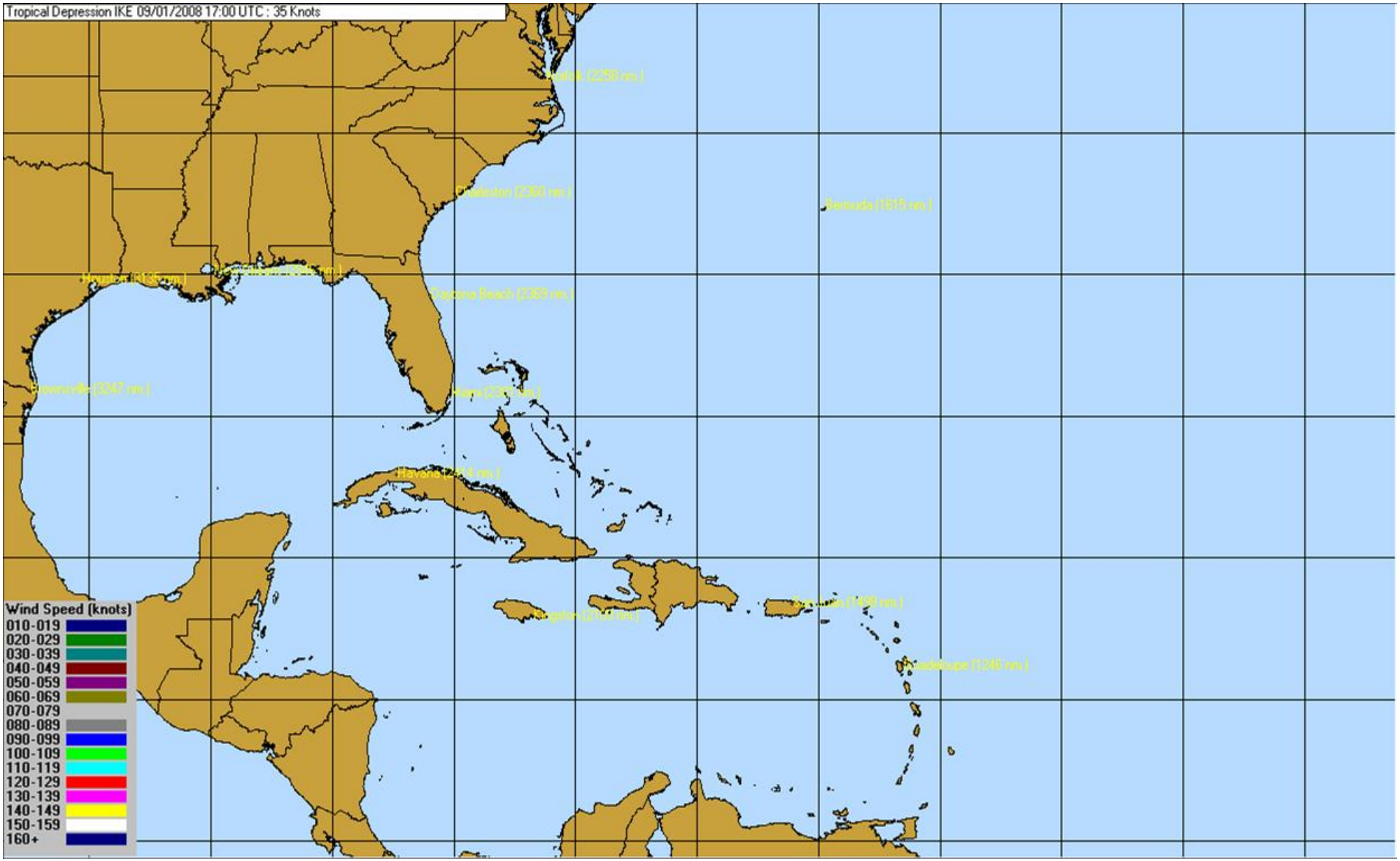
ISS017E015703

Cuban Radar Imagery of IKE Re-emerging over the Caribbean after Being “Hollowed Out” During Its Passage over Mountainous Terrain of Eastern Cuba

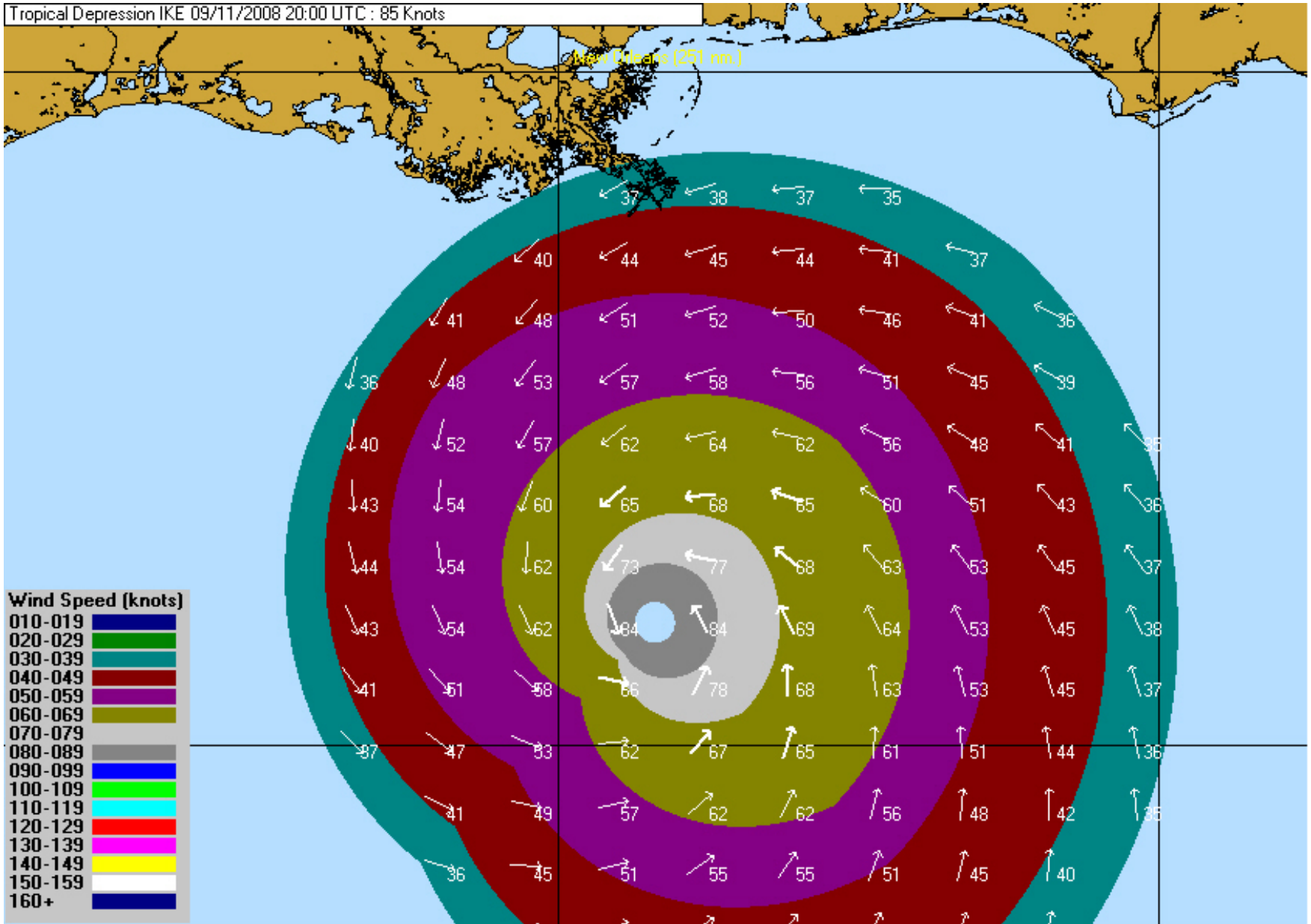
Hurricane Ike Emerges into Gulf and Crosses Loop Current



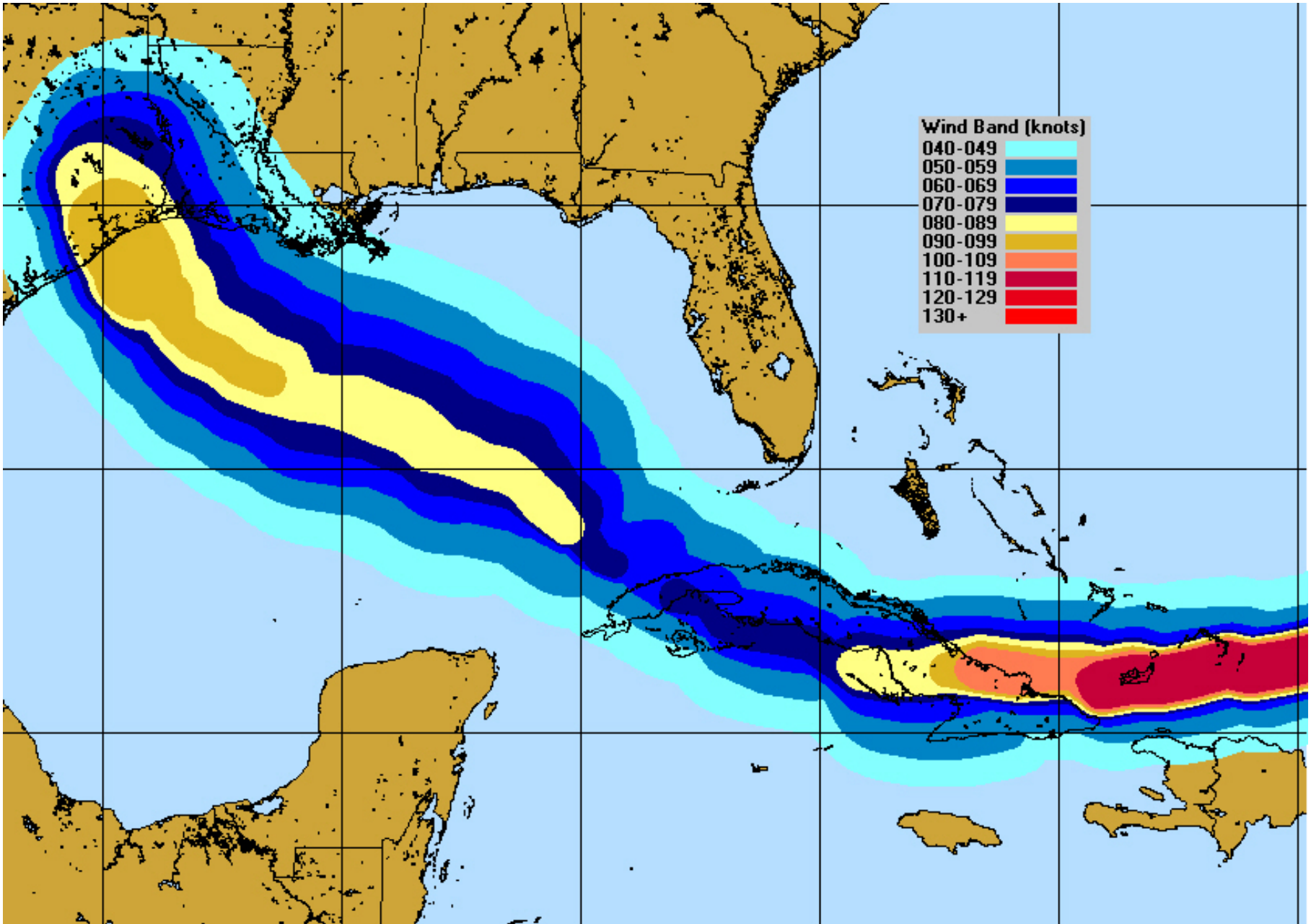
Wind Envelope History of Hurricane IKE



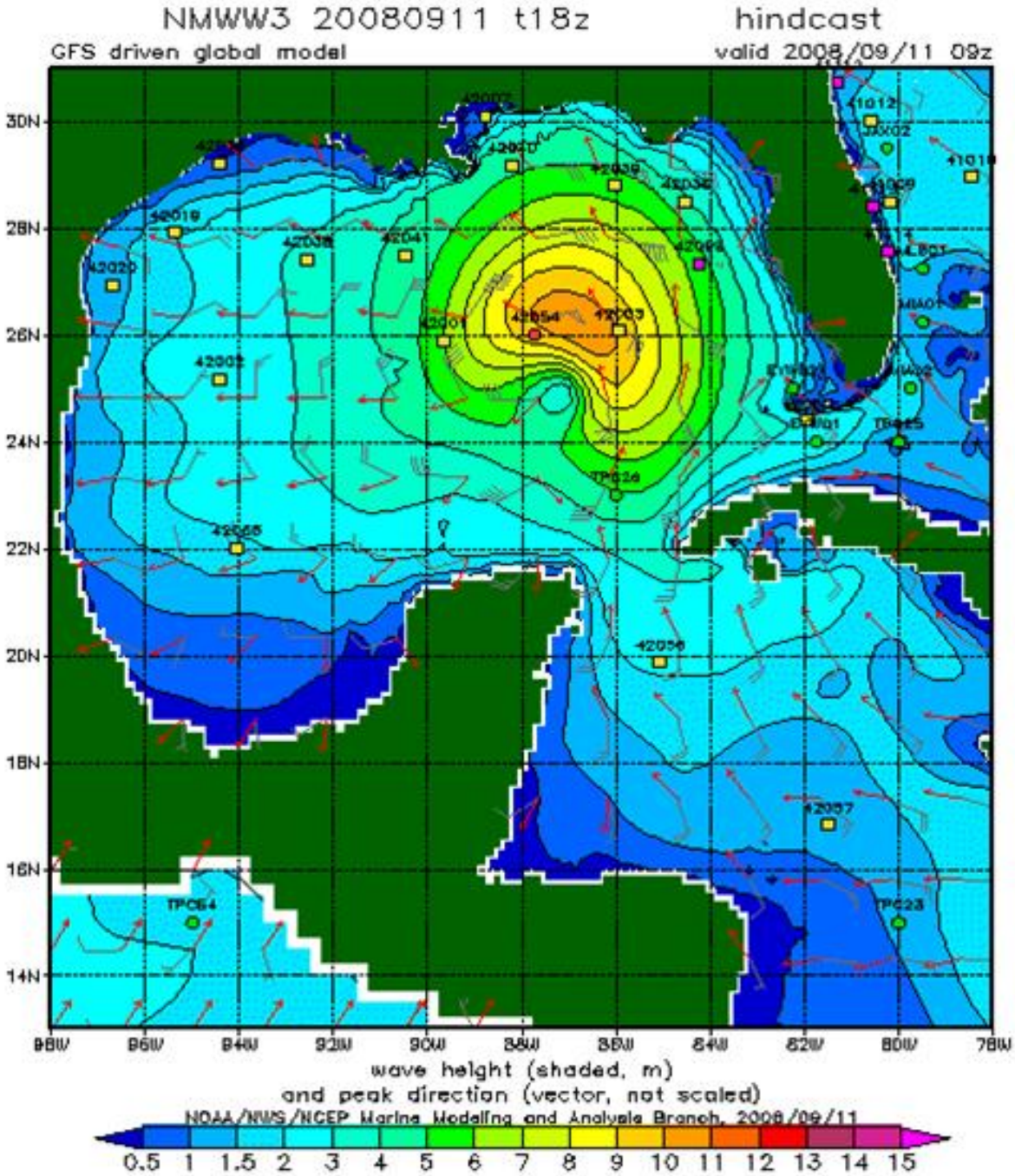
Ike Wind Field on the Afternoon of 11 Sept



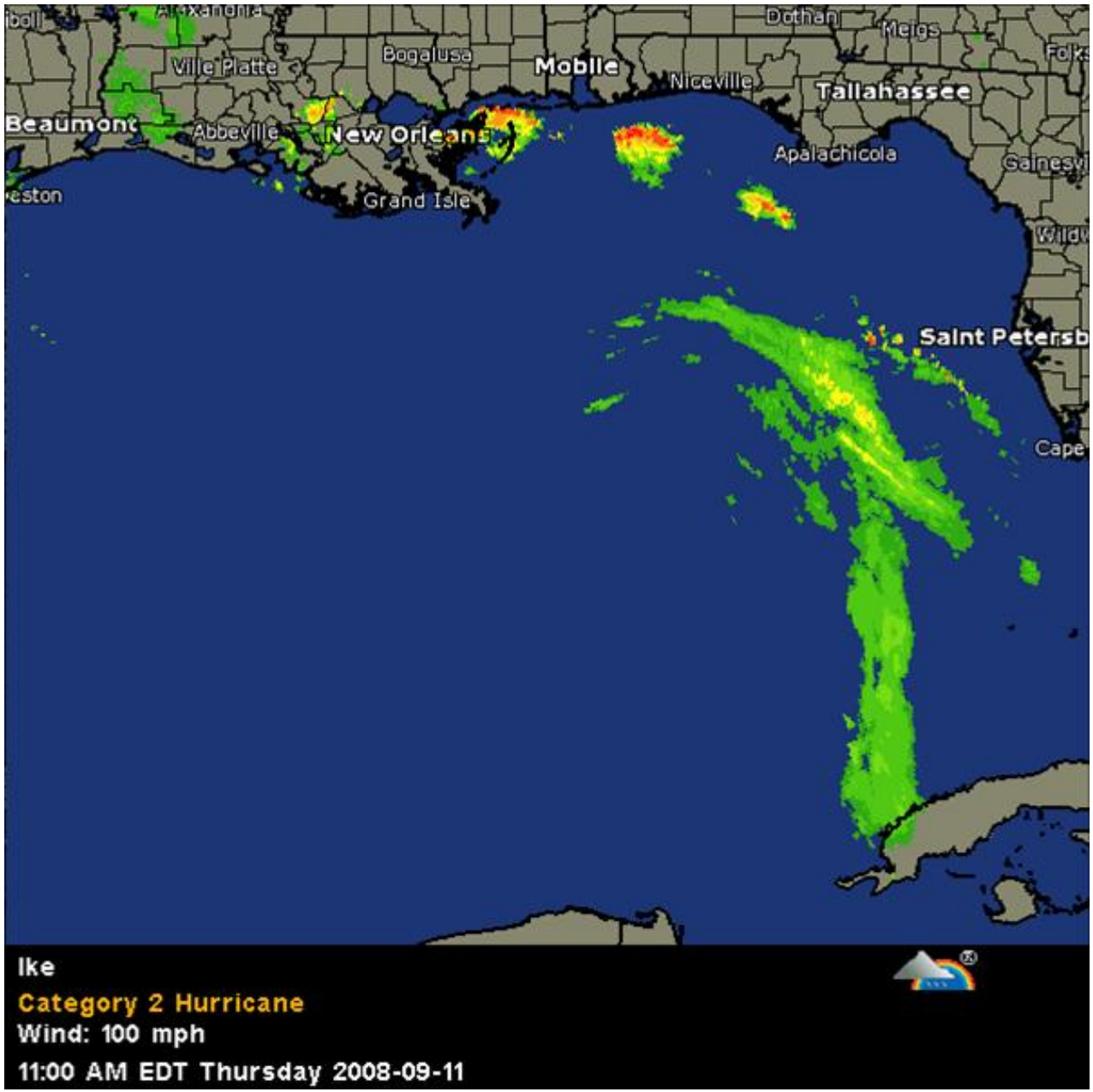
IKE Wind Swath History



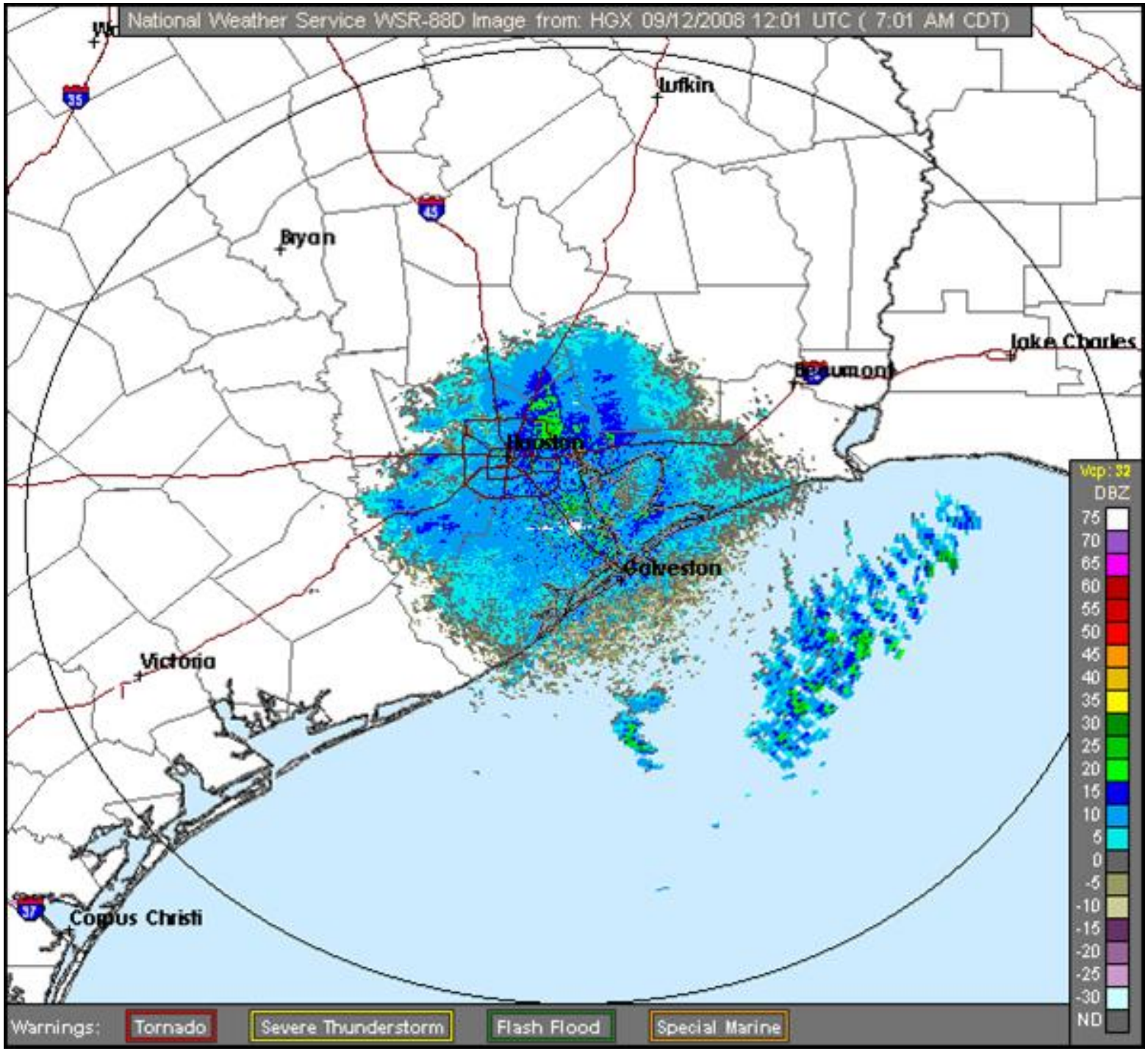
NOAA Wave Modeling of IKE



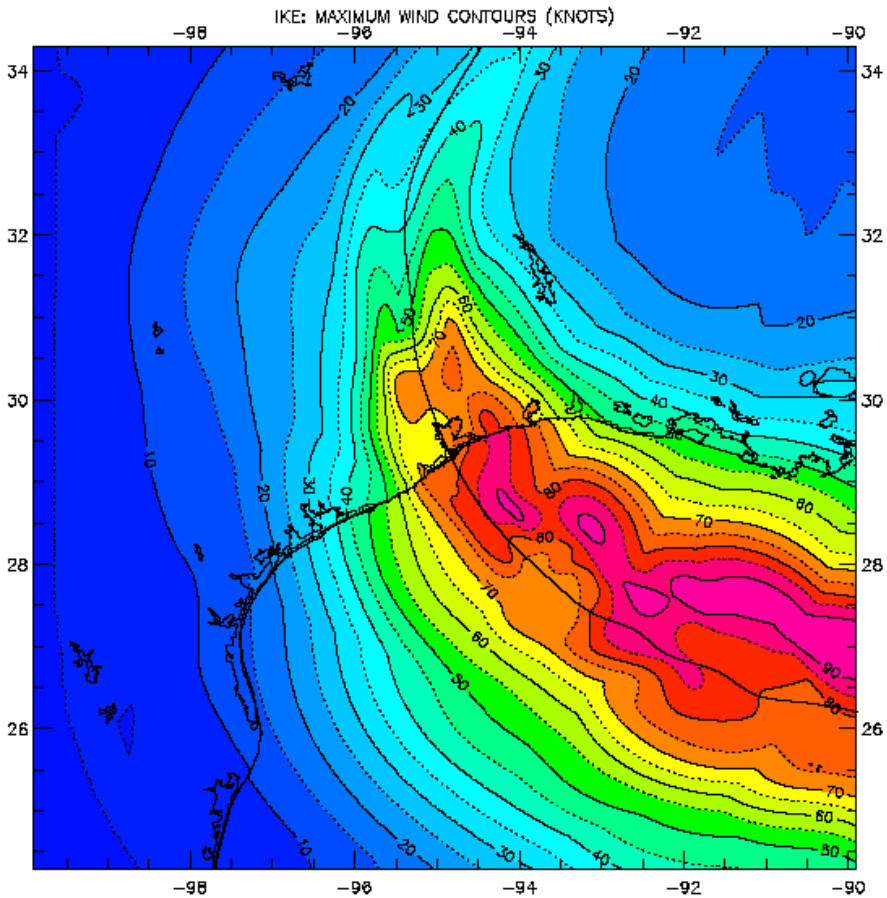
Radar Imagery of Ike Moving Through the Gulf Approaching Texas

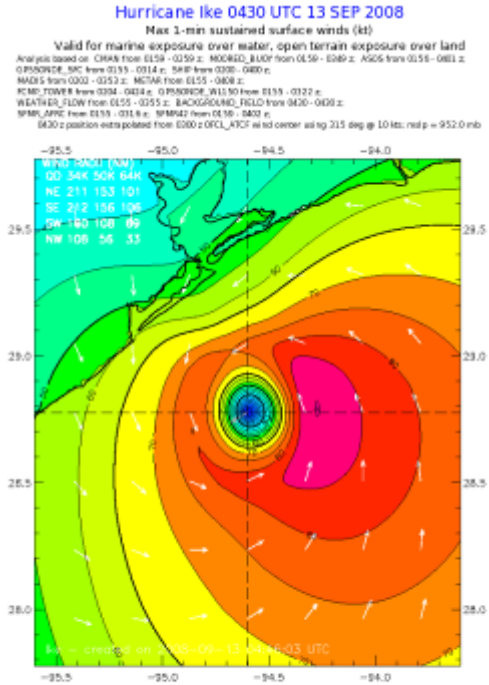


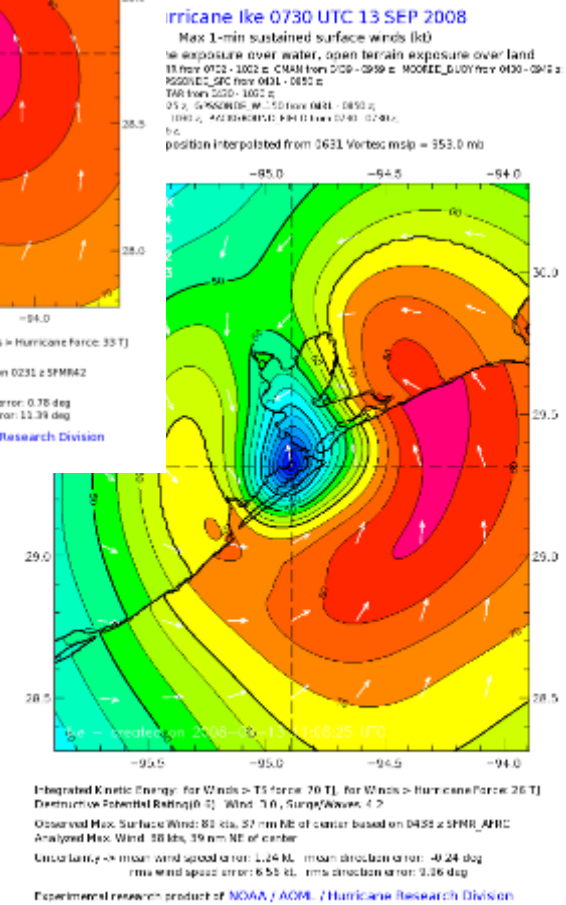
Galveston Radar Imagery Showing the Arrival of Hurricane IKE



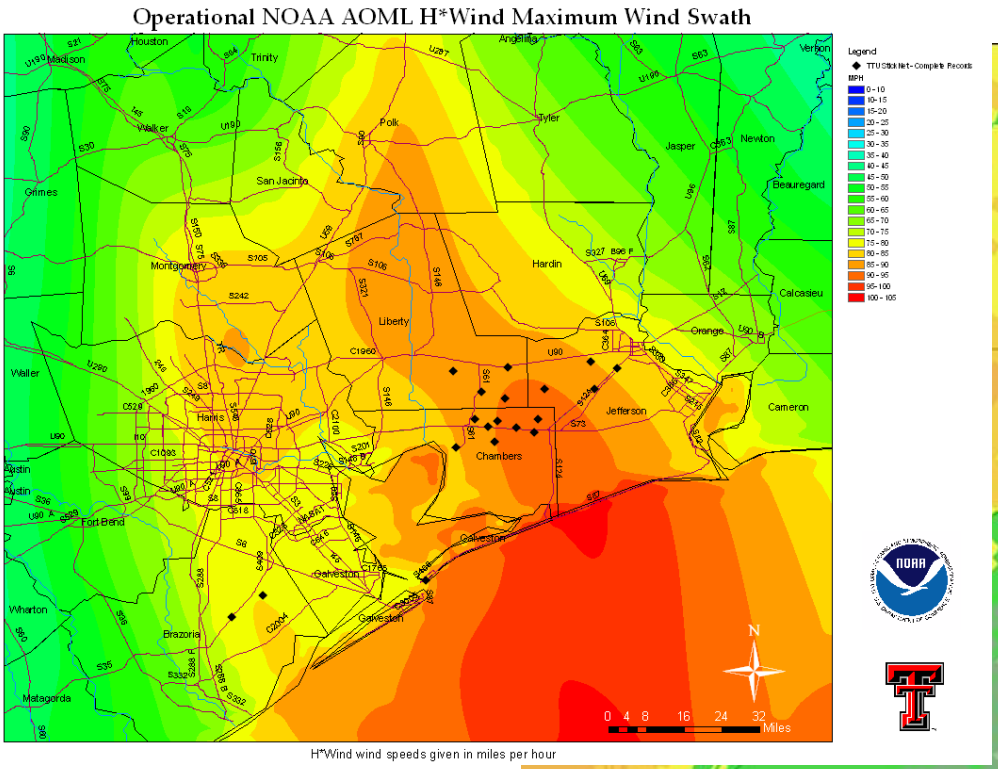
NOAA HRD H*WIND Estimates for IKE Near TX Landfall

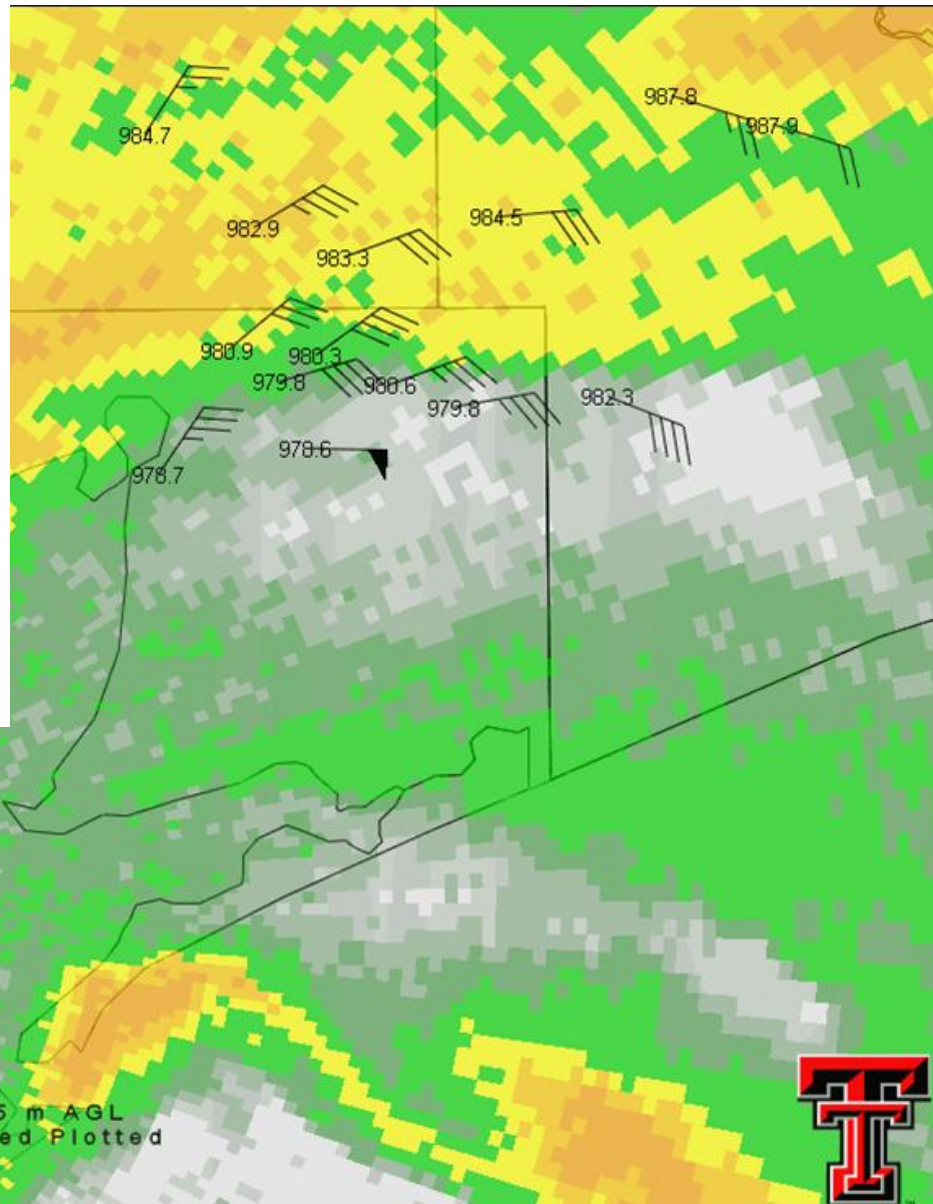




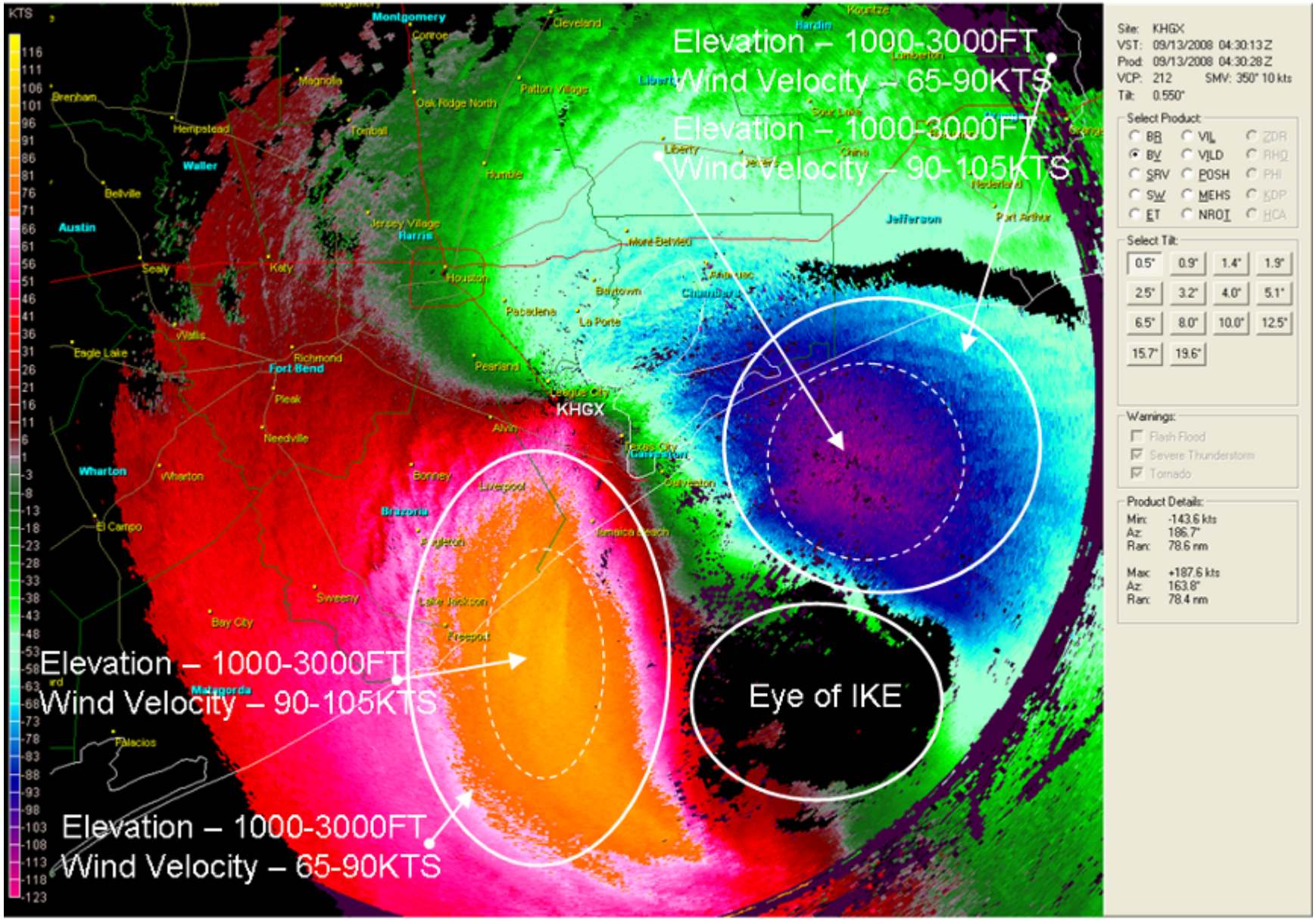


Finer scale H*WIND Estimates of Max Sustained Surface Winds Using Texas Tech Wind Towers Correlated with Radar





Doppler Radar Imagery of Ike Near Landfall



- URNT12 KNHC 130245 CCA
- VORTEX DATA MESSAGE AL092008
- A. 13/02:35:40Z
- B. 28 deg 31 min N
- 094 deg 24 min W
- C. 700 mb 2704 m
- D. 89 kt
- E. 266 deg 025 nm
- F. 357 deg 083 kt
- G. 268 deg 036 nm
- H. 953 mb
- I. 10 C/ 3051 m
- J. 16 C/ 3050 m
- K. 12 C/ NA
- L. OPEN NE
- M. C50
- N. 12345/ 7
- O. 0.02 / 1 nm
- P. AF304 3309A IKE OB 35 CCA
- MAX OUTBOUND WIND AND MAX FL WIND 107 KT E QUAD 02:45:30 Z

- **UZNT13 KNHC 130158**
- **XXAA 63027 99289 70941 08284 99963 25604 09080 00836 ///// /////**
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- **31313 09608 80143**
- **61616 AF304 3309A IKE OB 30**
- **62626 EYEWALL 045 SPL 2891N09416W 0147 MBL WND 09598 AEV 00000 DLM WND 11097 962707 WL150 09087 081 =**
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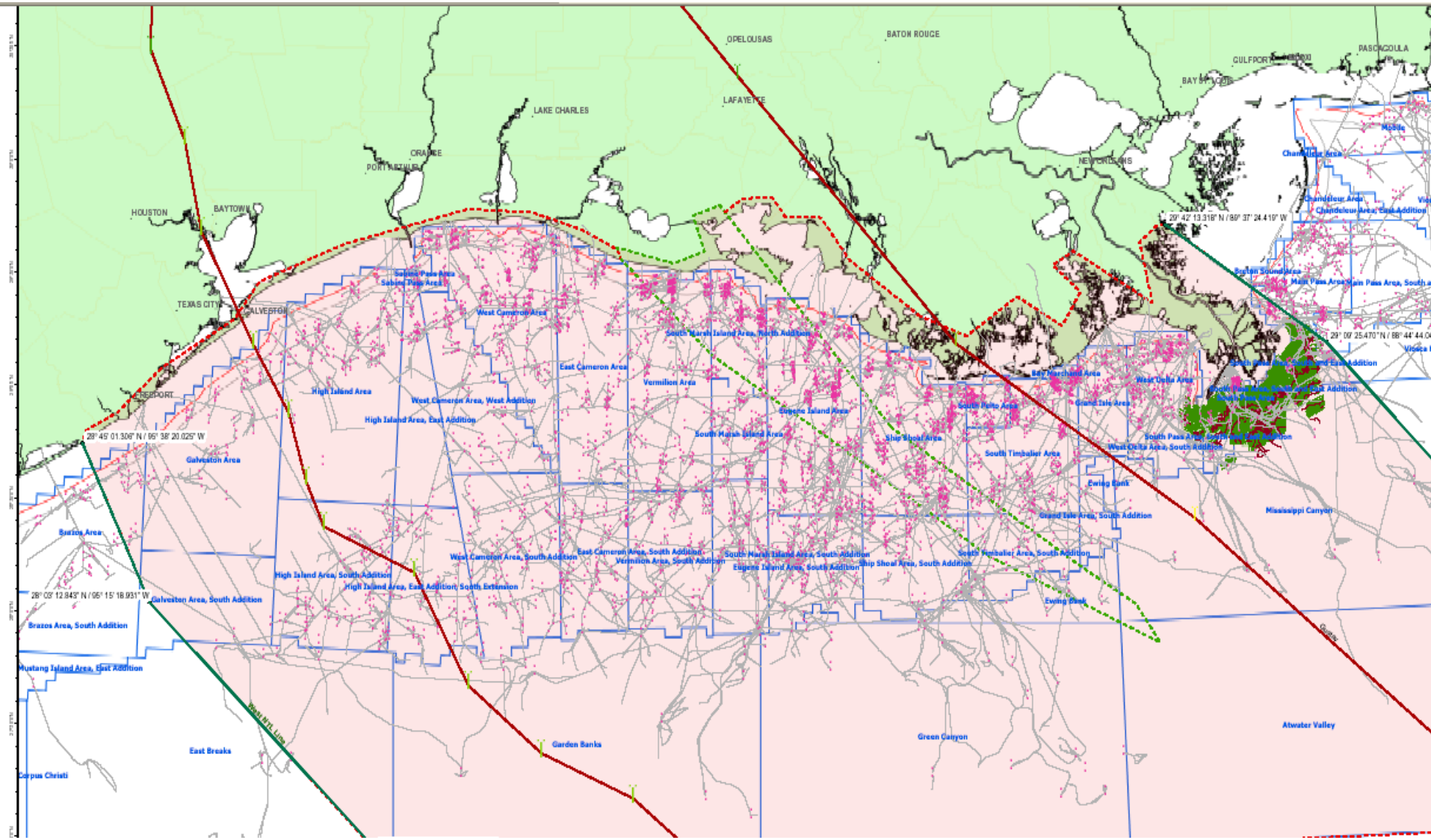
- **31313 09608 80438**
- **61616 AF301 3509A IKE1 OB 05**
- **62626 EYEWALL 045 SPL 2911N09415W 0442 MBL WND 13606 AEV 00000 DLM WND 14600 959710 WL150 12592 075 =**
- **XXBB 63058 99290 70941 08294 00959 26200 11850 21600 22706 16809**
- **33697 14005**
- **21212 00959 12581 11954 12587 22946 12603 33929 13608 44918 13623**
- **55899 14608 66885 15113 77859 15102 88850 15103 99697 16096**
- **31313 09608 80438**
- **61616 AF301 3509A IKE1 OB 05**
- **62626 EYEWALL 045 SPL 2911N09415W 0442 MBL WND 13606 AEV 00000 DLM WND 14600 959710 WL150 12592 075 =**

NOAA “Before and After” Aerial Photos of Bolivar Peninsula, TX


September 9, 2008


September 15, 2008
USGS

Impact of Gustav and Ike



Summary

- Transformation into an abnormally large tropical cyclone, such as Ike, exposes a much greater number of Gulf facilities to 12–25 foot significant wave heights (impacting operations and creating damage)
- However, the total energy of the wave action, while dispersed over a larger area, may NOT pose as much threat of destruction to any one particular location (with the formation of huge waves (25–50+ feet) less likely) as what is seen with more intense but smaller hurricanes (ie: Ivan, Rita, Cat 5 (28 Aug) Katrina)