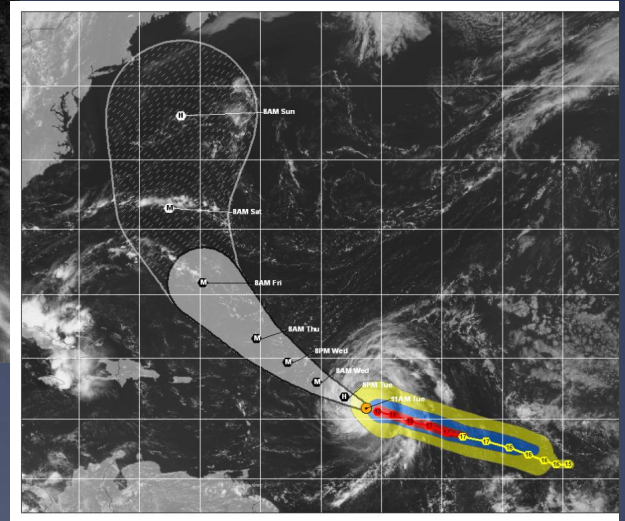


Hurricane Forecasting in the Western Hemisphere



Bill Read, Director
National Hurricane Center

Ancient Mayan Civilization

Most sites well inland



Mayan Hurricane Center?

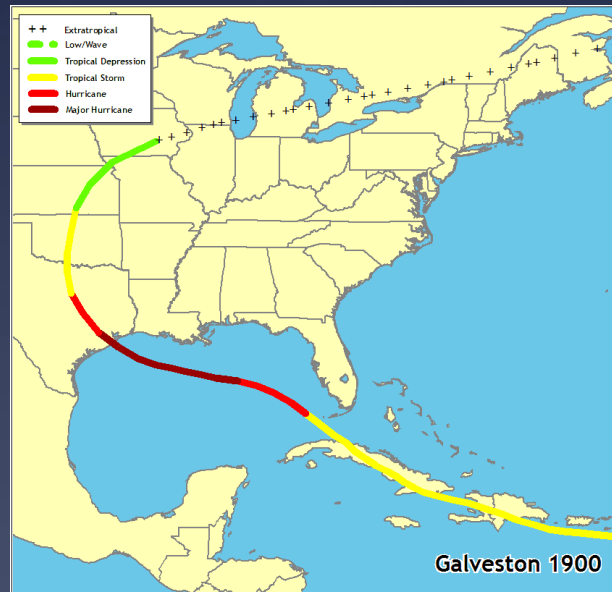


1800 -1900 forecasting

- * Viñes and others (Cuba)
- * Observing networks
- * Climatology of storms
- * Short term forecasting techniques based on sky condition, waves, barometric tendency

1900 Galveston

- * All warnings issued from Washington
- * Flags
- * Door to Door...no one outside Galveston would Get the “warning”



1900 to 1940

- * Ship to shore radio added observations at sea
- * Early upper air
- * Advances in the conceptual models of hurricane structure, track and intensity
- * 1935 hurricane forecast service decentralized to Jacksonville, New Orleans, San Juan, and a regional responsibility in DC

WW II

- * Upper Air observations
- * Hurricane reconnaissance
- * Experientially trained workforce
- * Many of us benefited by instruction from WW II vets turned professors



1940s advisory

MIAMI WEATHER BUREAU ADVISORY NUMBER EIGHT 2:00PM EST OCT 11, 1947.

HOIST HURRICANE WARNINGS 2:00PM FROM KEY WEST TO PUNTA GORDA.

THE TROPICAL STORM HAS INCREASED TO FULL HURRICANE FORCE OVER A VERY ~~SMALL~~ SMALL AREA NEAR THE ~~RENTON~~ CENTER. IT WAS VERY NEAR DRY TORTUGAS AT TWO PM EST 1900Z LATITUDE 24.6 LONGITUDE 82.8 MOVING NORTH NORTHEASTWARD ABOUT 18 MPH? HIGHEST WINDS AT DRY TORTUGAS ESTIMATED ~~OVER~~ 100 MPH.

THE CENTER SHOULD CONTINUE NORTH NORTHEAST MOVEMENT AND REACH THE COAST NEAR ~~ERXSLIGHT~~ FT MYERS TONIGHT.

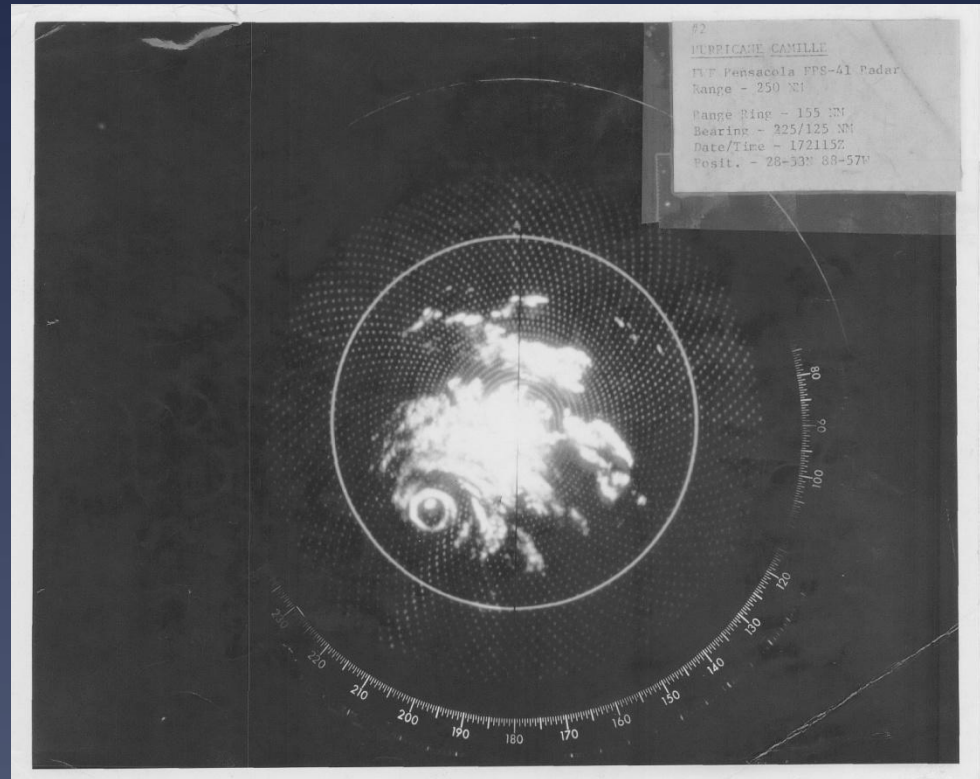
EVERY EMERGENCY PRECAUTION SHOULD BE TAKEN IMMEDIATELY FROM KEY WEST TO PUNTA GORDA. HEAVY SQUALLS AND GALES WILL BE FELT OVER ALL OTHER SECTIONS OF SOUTH FLORIDA FROM TAMPA AND DAYTONA BEACH SOUTHWARD DURING THE NEXT 24 HOURS.

HURRICANE WARNINGS ARE DISPLAYED FROM KEY WEST TO PUNTA GORDA AND STORM WARNINGS ELSEWHERE FROM TAMPA AND DAYTONA BEACH SOUTHWARD.

NORTON WEATHER BUREAU

1950-1970 Observational Tools

- * Aircraft Recon
- * Early Satellite
- * Surface observations
- * Coastal radar



1970 Forecasting

- * Climatology, persistence, experiential (subjective) forecaster input
- * Early use of computer models (but the forecasters accepted them with open arms)
- * Statistical guidance

1970 products and services

- * Marine advisory via teletype
- * Public advisory via teletype
- * 24h warning
- * No formal media pool

CENTER

BULLETIN 1 PM CDT SUNDAY AUGUST 17, 1969

...CAMILLE...EXTREMELY DANGEROUS...CONTINUES TO MOVE TOWARD THE MOUTH OF THE MISSISSIPPI RIVER...THREATENS SOUTHEAST LOUISIANA COAST EASTWARD TO EXTREME NORTHWEST FLORIDA...

HURRICANE WARNINGS ARE IN EFFECT FROM NEW ORLEANS AND GRAND ISLE LOUISIANA EASTWARD ACROSS THE MISSISSIPPI...ALABAMA...AND...NORTH WEST FLORIDA COAST TO ST. MARKS. GALE WARNINGS ARE IN EFFECT ELSEWHERE FROM MORGAN CITY TO CEDAR KEYS FLORIDA. PREPARATIONS AGAINST THIS EXTREMELY DANGEROUS HURRICANE SHOULD BE COMPLETED WITHIN THE NEXT FEW HOURS.

WINDS ARE INCREASING AND TIDES ARE RISING ALONG THE NORTHERN GULF COAST FROM GRAND ISLE EASTWARD. GALES HAVE BEGUN AT THE MOUTH OF THE MISSISSIPPI RIVER AND WILL BE SPREADING INLAND OVER THE WARNING AREA THIS AFTERNOON WITH WINDS REACHING HURRICANE FORCE OVER MUCH OF THE AREA FROM SOUTHEAST LOUISIANA ACROSS COASTAL MISSISSIPPI...ALABAMA...AND INTO EXTREME NORTHWEST FLORIDA LATE THIS AFTERNOON OR EARLY TONIGHT. TIDES UP TO 15 FEET ARE EXPECTED IN THE AREA WHERE THE CENTER CROSSES THE COAST AND TIDES OF 5 TO 12 FEET ELSEWHERE IN THE HURRICANE WARNING AREA. EVACUATION OF THE LOW LYING AREA THAT WILL BE AFFECTED BY THESE TIDES SHOULD BE DONE AS EARLY AS POSSIBLE BEFORE ESCAPE ROUTES ARE CLOSED. THE CENTER OF CAMILLE IS EXPECTED TO PASS CLOSE TO THE MOUTH OF THE MISSISSIPPI RIVER LATE THIS AFTERNOON AND MOVE INLAND ON THE MISSISSIPPI COAST TONIGHT.

SEVERAL TORNADOES ARE LIKELY OVER EXTREME SOUTHEAST LOUISIANA EASTWARD TO FORT WALTON FLORIDA AND UP TO 100 MILES INLAND THIS AFTERNOON AND TONIGHT.

HEAVY RAIN WITH LOCAL AMOUNTS 8 TO 10 INCHES WILL SPREAD INTO SOUTHEASTERN MISSISSIPPI...SOUTHWEST ALABAMA...AND THE FLORIDA PANHANDLE THIS AFTERNOON AND TONIGHT. ANY FLOOD STATEMENTS NEEDED WILL BE ISSUED BY LOCAL WEATHER BUREAU OFFICES.

ALL INTERESTS ALONG THE NORTHEASTERN GULF COAST ARE URGED TO LISTEN FOR LATER RELEASES AND TAKE ALL NECESSARY HURRICANE PRECAUTIONS IMMEDIATELY.

AT 1 PM CDT...HURRICANE CAMILLE WAS LOCATED NEAR LATITUDE 28.1 NORTH...LONGITUDE 88.6 WEST...OR ABOUT 155 MILES SOUTHEAST OF NEW ORLEANS. CAMILLE WAS MOVING NORTH NORTHWEST 12 TO 15 MPH. A CHANGE TO A SLIGHTLY MORE NORTHERLY COURSE IS LIKELY AS THE CENTER APPROACHES THE COAST.

HIGHEST WINDS ARE ESTIMATED 160 MPH NEAR THE CENTER AND LITTLE CHANGE IN INTENSITY IS EXPECTED.

REPEATING THE 1 PM POSITION...28.1 NORTH...88.6 WEST.

THE NEXT ADVISORY WILL BE ISSUED BY THE NEW ORLEANS WEATHER BUREAU AT 5 PM AND A BULLETIN AT 3 PM CDT.

CONNER

ESSA WEATHER BUREAU MARINE/AVIATION ADVISORY NUMBER 2 HURRICANE CAMILLE 1600Z AUGUST 15 1969

HURRICANE CENTER LOCATED NEAR LATITUDE 21.2 NORTH LONGITUDE 83.9 WEST AT 15/1600Z. POSITION GOOD ACCURATE WITHIN 20 MILES BASED ON ESSA RECONNAISSANCE SATELLITE AND SYNOPTIC REPORTS.

PRESENT MOVEMENT TOWARD THE NNW OR 340 DEGREES AT 8 KT.
MAX SUSTAINED WINDS OF 95 KT NEAR CENTER.
MAX WINDS OVER INLAND AREAS 50 KT.
RAD OF 65 KT WINDS 30 NE QUAD
RAD OF 50 KT WINDS 45 NE 20 SE 20 SW 45 NW QUAD.
RAD OF 30 KT WINDS 125 NE 50 SE 50 SW 125 NW QUAD.
REPEAT CENTER LOCATED 21.2N 83.9W AT 15/1600Z.

12 HOUR FORECAST VALID 16/0000Z LATITUDE 22.2 N LONGITUDE 84.2W.
MAX WINDS OF 80 KT NEAR CENTER.
MAX WINDS OVER INLAND AREAS 80 KT.
RADIUS OF 50 KT WINDS 45 NE 0 SE 20 SW 45 NW QUAD.
8 HOUR FORECAST VALID 16/1200Z LATITUDE 24.3 N LONGITUDE 84.6W.
MAX WINDS OF 100 KT NEAR CENTER.
MAX WINDS OVER INLAND AREAS 35 KT.
RADIUS OF 50 KT WINDS 45 NE 20 SE 20 SW 45 NW QUAD.

STORM SURGE OF UP TO 8 FEET WESTERN TIP OF CUBA.

HEAVY PRECIPITATION WESTERN CUBA.

TCD in 1969

MVNVM
 DD MJSJYM
 CARCAH
 7072
 ALCKT 23421 MKCC A MIAC ALCKT 23420
 30GT2352 (Navy)

RECEIVED
 AUG 18 10 52 AM '69
 TROPICAL CYCLONE CENTER BUREAU

FOR OFFICIAL USE ONLY

17 / ~~0000Z~~ / ~~0000Z~~ / 1500Z ~~2100Z~~

NATIONAL HURRICANE CENTER

MIAMI TROPICAL CYCLONE DISCUSSION HURRICANE / ~~STORM~~ / ~~DEPRESSION~~

CAMILLE
 (name)

ATTN: FAMS NMC A and FD

LATEST 500 MB AND TROPOSPHERIC ~~MIN~~ ^{MEAN} CIRCULATION CHARTS INDICATE LITTLE IF ANY ~~ENH~~ TURNING TO THE RIGHT FOR THE NEXT FEW HOURS AND ONLY SLIGHT TURNING THEREAFTER BEFORE LANDFALL. THE HURRICANE HAS INCREASED IN SIZE SINCE YESTERDAY. NO NEW INFORMATION HAS BEEN RECEIVED ON THE LOWEST CENTRAL PRESSURE.

(PANNAR ONLY USE CUT-OFF CODE)

PRELIM PROG PSNS

INITIAL	<u>17</u> (date)	0400Z 1000Z 1600Z 2000Z	<u>27.6</u>	N	<u>88.5</u>	W
12 HR VT	<u>18</u> (date)	1200Z 1800Z 0000Z 0600Z	<u>29.2</u>	N	<u>89.1</u>	W
24 HR VT	<u>18</u> (date)	0000Z 0600Z 1200Z 1800Z	<u>31.2</u>	N	<u>89.1</u>	W
48 HR VT	<u>19</u> (date)	0000Z 0600Z 1200Z 1800Z	<u>35.0</u>	N	<u>86.0</u>	W
72 HR VT	(date)	0000Z 0600Z 1200Z 1800Z		N		W

(Cover 24 hr. fcst, 24-48 hr. fcst and 48-72 hr. otlk as related to synoptic features, objective techniques, climate, etc. Give reasons for intensity or track changes. Include plans for warnings display. Issued daily when advisories are issued.)

Computer Guidance 1969

COMPUTE DATA

PHONE TO NMC 0115Z-2115EDT 0715Z-0315EDT 1315Z-0915EDT 1915Z-151EDT
 DEPRESSION/STORM/HURRICANE DAY 16 MONTH AUG POSITION 18Z
 24.7 N 86.1 W. 12 HRS AGO 23.0 N 85.0 W. 24 HRS AGO 21.1 N 84.1 W.
 FOR LOCAL USE ONLY - 1000-400 MBS 1000-300 MBS 1000-200 MBS 1000-100 MBS
 CYCLONE - 991 MBS 990-971 MBS 940-970 MBS 939 MBS OR LESS
 CROSS OUT THREE OF THE ABOVE INCREMENTS. TELL NMC TO USE PROG AT 06 & 18Z.

COMPUTE DATA

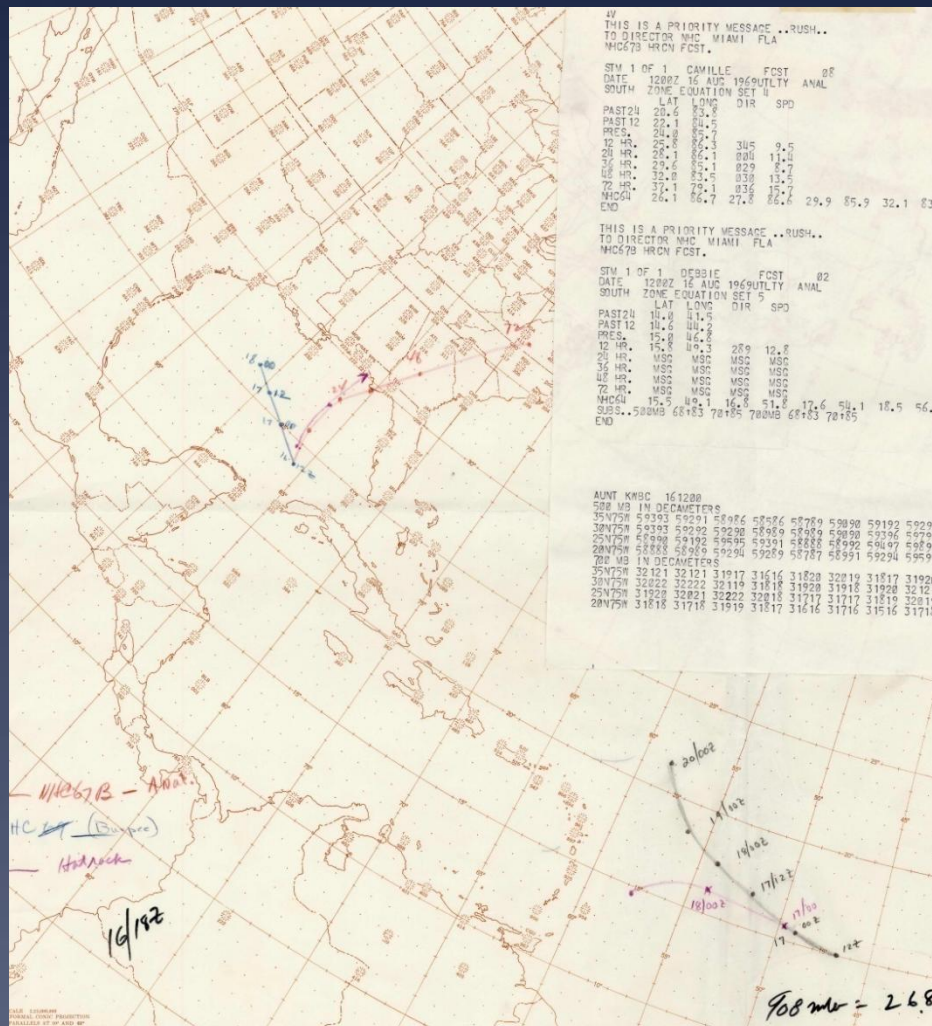
PHONE TO NMC 0115Z-2115EDT 0715Z-0315EDT 1315Z-0915EDT 1915Z-151EDT
 DEPRESSION/STORM/HURRICANE DAY 17 MONTH AUG POSITION 00Z
 25.4 N 87.2 W. 12 HRS AGO 23.8 N 86.0 W. 24 HRS AGO 22.3 N 84.5 W.
 FOR LOCAL USE ONLY - 1000-400 MBS 1000-300 MBS 1000-200 MBS 1000-100 MBS
 CYCLONE - 991 MBS 990-971 MBS 940-970 MBS 939 MBS OR LESS
 CROSS OUT THREE OF THE ABOVE INCREMENTS. TELL NMC TO USE PROG AT 06 & 18Z.

COMPUTE DATA

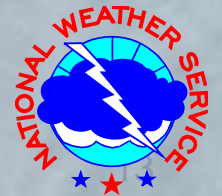
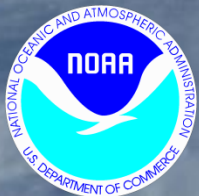
PHONE TO NMC 0115Z-2115EDT 0715Z-0315EDT 1315Z-0915EDT 1915Z-151EDT
 DEPRESSION/STORM/HURRICANE DAY 17 MONTH AUG POSITION 06Z 06Z 18Z 18Z
 26.4 N 87.5 W. 12 HRS AGO 24.4 N 86.2 W. 24 HRS AGO 23.0 N 85.0 W.
 FOR LOCAL USE ONLY - 1000-400 MBS 1000-300 MBS 1000-200 MBS 1000-100 MBS
 CYCLONE - 991 MBS 990-971 MBS 940-970 MBS 939 MBS OR LESS
 CROSS OUT THREE OF THE ABOVE INCREMENTS. TELL NMC TO USE PROG AT 06 & 18Z.

COMPUTE DATA

PHONE TO NMC 0115Z-2115EDT 0715Z-0315EDT 1315Z-0915EDT 1915Z-151EDT
 DEPRESSION/STORM/HURRICANE DAY 17 MONTH AUG POSITION 12Z
 27.2 N 88.1 W. 12 HRS AGO 25.2 N 87.2 W. 24 HRS AGO 23.8 N 86.0 W.
 FOR LOCAL USE ONLY - 1000-400 MBS 1000-300 MBS 1000-200 MBS 1000-100 MBS
 CYCLONE - 991 MBS 990-971 MBS 940-970 MBS 939 MBS OR LESS
 CROSS OUT THREE OF THE ABOVE INCREMENTS. TELL NMC TO USE PROG AT 06 & 18Z.

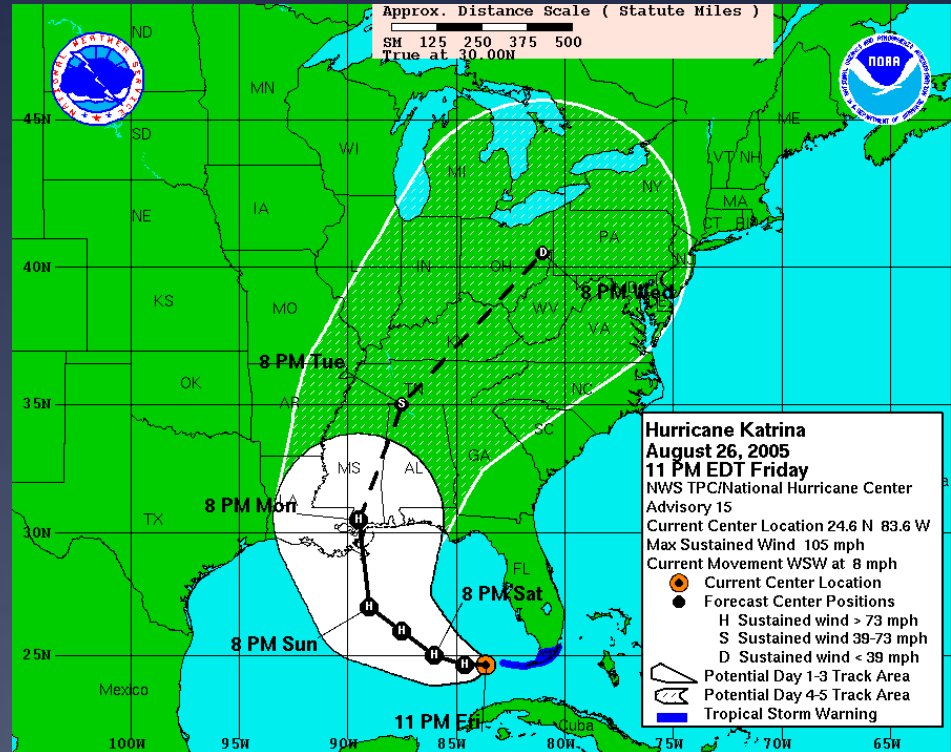


Hurricane Forecasting -2010



What we forecast

- * Center position out 120 hours
- * Watch 48h warning 36h
- * Forward speed
- * Maximum intensity
- * Size out 72 hours
- * Surge 24-36 hours
- * Rainfall
- * Tornadoes



“Products”....

The screenshot shows the National Weather Service National Hurricane Center website. The header includes the NOAA logo, the text "National Weather Service National Hurricane Center", and the "weather.gov" logo. A navigation bar contains "Home", "News", "Organization", "Search", and "Go". A search box is present next to "Go". Below the navigation bar, there is a "Local forecast by 'City, St' or 'ZIP'" section with a "Go" button. A sidebar on the left lists various services and resources, including "Alternate versions", "Get Storm Info", "Marine Forecasts", "Hurricane Awareness", "Hurricane History", and "About the NHC". The main content area is titled "Tropical Storm IDA" and contains a bulletin from the National Hurricane Center in Miami, FL, dated November 9, 2009. The bulletin text is as follows:

ZCZC MIATCPATI ALL
TTAAOO KNHC DDHMM
BULLETIN
TROPICAL STORM IDA ADVISORY NUMBER 24
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112009
300 PM CST MON NOV 09 2009

...IDA TURNS NORTHWARD...SHOULD MAKE LANDFALL OVERNIGHT...

A TROPICAL STORM WARNING REMAINS IN EFFECT FROM GRAND ISLE LOUISIANA EASTWARD TO THE AUCILLA RIVER FLORIDA...INCLUDING NEW ORLEANS AND LAKE PONTCHARTRAIN. A TROPICAL STORM WARNING MEANS THAT TROPICAL STORM CONDITIONS ARE EXPECTED SOMEWHERE WITHIN THE WARNING AREA WITHIN 24 HOURS.

FOR STORM INFORMATION SPECIFIC TO YOUR AREA IN THE UNITED STATES...INCLUDING POSSIBLE INLAND WATCHES AND WARNINGS...PLEASE MONITOR PRODUCTS ISSUED BY YOUR LOCAL NATIONAL WEATHER SERVICE FORECAST OFFICE.

AT 300 PM CST...2100 UTC...THE CENTER OF TROPICAL STORM IDA WAS LOCATED NEAR LATITUDE 28.4 NORTH...LONGITUDE 88.5 WEST OR ABOUT 60 MILES... 95 KM...SOUTHEAST OF THE MOUTH OF THE MISSISSIPPI RIVER AND ABOUT 165 MILES...265 KM...SOUTH-SOUTHWEST OF PENSACOLA FLORIDA.

IDA IS MOVING TOWARD THE NORTH NEAR 18 MPH...30 KM/HR. A REDUCTION IN FORWARD SPEED IS EXPECTED OVERNIGHT. ON THE FORECAST TRACK...THE CENTER OF IDA SHOULD REACH THE NORTHERN GULF COAST TONIGHT. AFTER LANDFALL...IDA IS EXPECTED TO TURN EASTWARD ON TUESDAY.

MAXIMUM SUSTAINED WINDS ARE NEAR 70 MPH...110 KM/HR...WITH HIGHER GUSTS. WEAKENING IS EXPECTED THIS EVENING AS IDA MOVES OVER COOLER WATERS PRIOR TO MAKING LANDFALL...AND IS EXPECTED TO MERGE WITH A FRONTAL ZONE ON WEDNESDAY.

TROPICAL STORM FORCE WINDS EXTEND OUTWARD UP TO 200 MILES...325 KM FROM THE CENTER.

THE LATEST MINIMUM CENTRAL PRESSURE REPORTED BY AN AIR FORCE RESERVE HURRICANE HUNTER AIRCRAFT WAS 991 MB...29.26 INCHES.

RAINS FROM IDA ARE ALREADY MOVING ACROSS THE COAST WITHIN THE WARNING AREA. TOTAL STORM ACCUMULATIONS OF 3 TO 6 INCHES...WITH ISOLATED MAXIMUM STORM TOTALS OF 8 INCHES...ARE POSSIBLE THROUGH WEDNESDAY EVENING FROM THE CENTRAL AND EASTERN GULF COAST ACROSS THE SOUTHEASTERN UNITED STATES INTO THE SOUTHERN MID-ATLANTIC STATES.

A DANGEROUS STORM TIDE WILL RAISE WATER LEVELS BY AS MUCH AS 3 TO 5 FEET ABOVE GROUND LEVEL ALONG THE COAST NEAR AND TO THE EAST OF WHERE THE CENTER MAKES LANDFALL...AS WELL AS IN AREAS OF ONSHORE FLOW IN SOUTHEASTERN LOUISIANA. NEAR THE COAST...THE SURGE

000
WTUS84 KLIX 092204
HLSLIX

URGENT - IMMEDIATE BROADCAST REQUESTED
TROPICAL STORM IDA LOCAL STATEMENT
NATIONAL WEATHER SERVICE NEW ORLEANS LA
404 PM CST MON NOV 9 2009

...IDA TURNS NORTHWARD...SHOULD MAKE LANDFALL OVERNIGHT...

.AREAS AFFECTED...
THIS LOCAL STATEMENT PROVIDES IMPORTANT INFORMATION AND RECOMMENDED ACTIONS FOR PEOPLE IN SELECT LOCATIONS AND COASTAL WATERS OF SOUTHEAST LOUISIANA SOUTH MISSISSIPPI.

.WATCHES/WARNINGS...
A TROPICAL STORM WARNING CONTINUES FOR ALL OF SOUTHEAST LOUISIANA AND MISSISSIPPI COASTAL WATERS.

A TROPICAL STORM WIND WARNING CONTINUES FOR PORTIONS OF INLAND SOUTHEAST LOUISIANA AND SOUTH MISSISSIPPI.

A FLOOD WATCH IS IN EFFECT FOR PART OF SOUTHEAST LOUISIANA AND SOUTH MISSISSIPPI.

PLEASE CHECK THE LATEST PUBLIC AND MARINE FORECASTS FOR DETAILED INFORMATION ABOUT ADDITIONAL HAZARDS.

.STORM INFORMATION...
AT 3 PM CST...THE CENTER OF TROPICAL STORM IDA WAS LOCATED NEAR LATITUDE 28.4 NORTH...LONGITUDE 88.5 WEST...OR ABOUT 60 MILES SOUTHEAST OF THE MOUTH OF THE MISSISSIPPI RIVER. THIS IS ABOUT 150 MILES SOUTHEAST OF NEW ORLEANS LA...OR ABOUT 140 MILES SOUTH-SOUTHEAST OF GULFPORT MS. STORM MOTION WAS NORTH OR 355 DEGREES AT 18 MPH. STORM INTENSITY WAS 70 MPH.

.SITUATION OVERVIEW...
WHEN MAKING DECISIONS...DO NOT FOCUS ON THE EXACT FORECAST TRACK. THE TROPICAL STORM IS CURRENTLY MOVING NEAR THE SOUTHWEST PASS OF THE MISSISSIPPI RIVER. THE TROPICAL STORM IS THEN EXPECTED TO MAKE LANDFALL TONIGHT NEAR MOBILE, ALABAMA. THE MAIN THREATS FROM TROPICAL STORM IDA WILL INCLUDE HEAVY RAINFALL...STRONG WINDS...AND STORM SURGE ALONG THE COAST AND TIDAL LAKES.

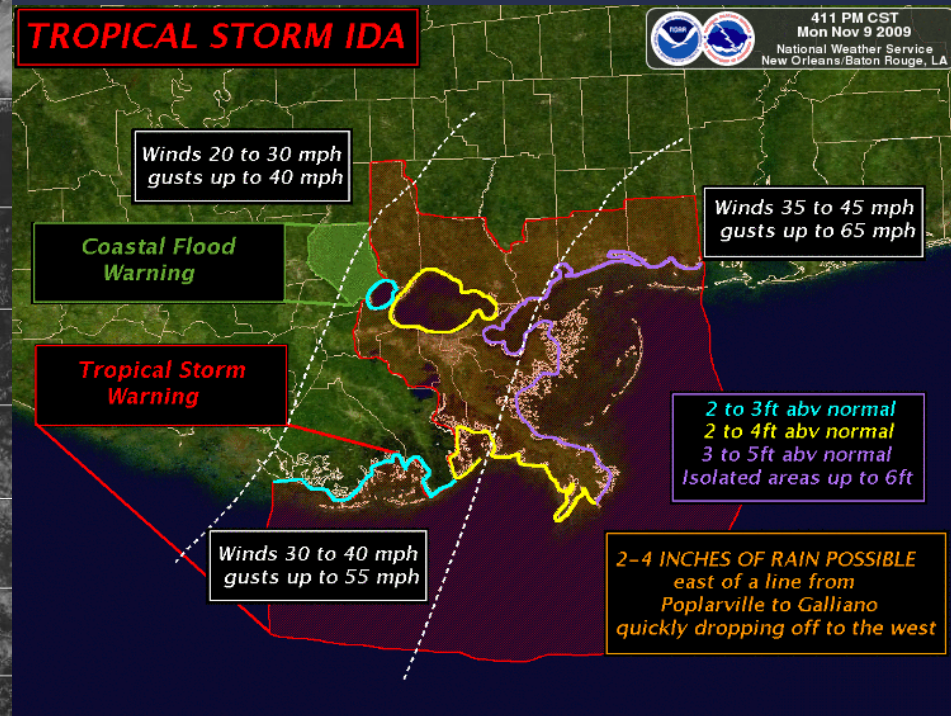
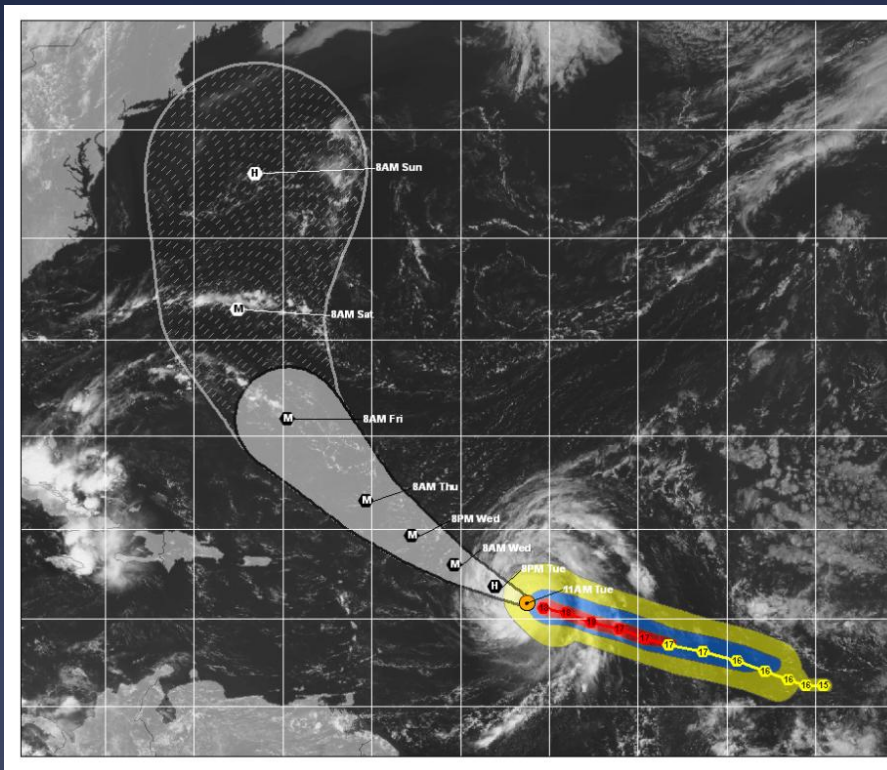
.PRECAUTIONARY/PREPAREDNESS ACTIONS...
DURING THE STORM...STAY INSIDE AND AWAY FROM WINDOWS. DO NOT VENTURE OUTSIDE WHEN HIGH WINDS ARE OCCURRING OR DURING TEMPORARY LULLS AS FLYING DEBRIS CAN EASILY...AND SUDDENLY...CAUSE SERIOUS INJURY.

HAVE A WELL CHARGED CELL PHONE NEARBY...KEEPING NETWORK COMMUNICATIONS AS OPEN AS POSSIBLE FOR EMERGENCIES. CLOSELY MONITOR NOAA WEATHER RADIO OR OTHER LOCAL NEWS OUTLETS FOR OFFICIAL STORM INFORMATION. LISTEN FOR POSSIBLE CHANGES TO THE FORECAST. FOR SMALL CRAFT WHO FAILED TO MAKE IT TO SAFE HARBOR OR PORT... AND ARE NOW IN DISTRESS...RADIO YOUR SITUATION ACCORDING

Plus one more page...

Plus 8 more pages...

...or “information”?



Keys to current success

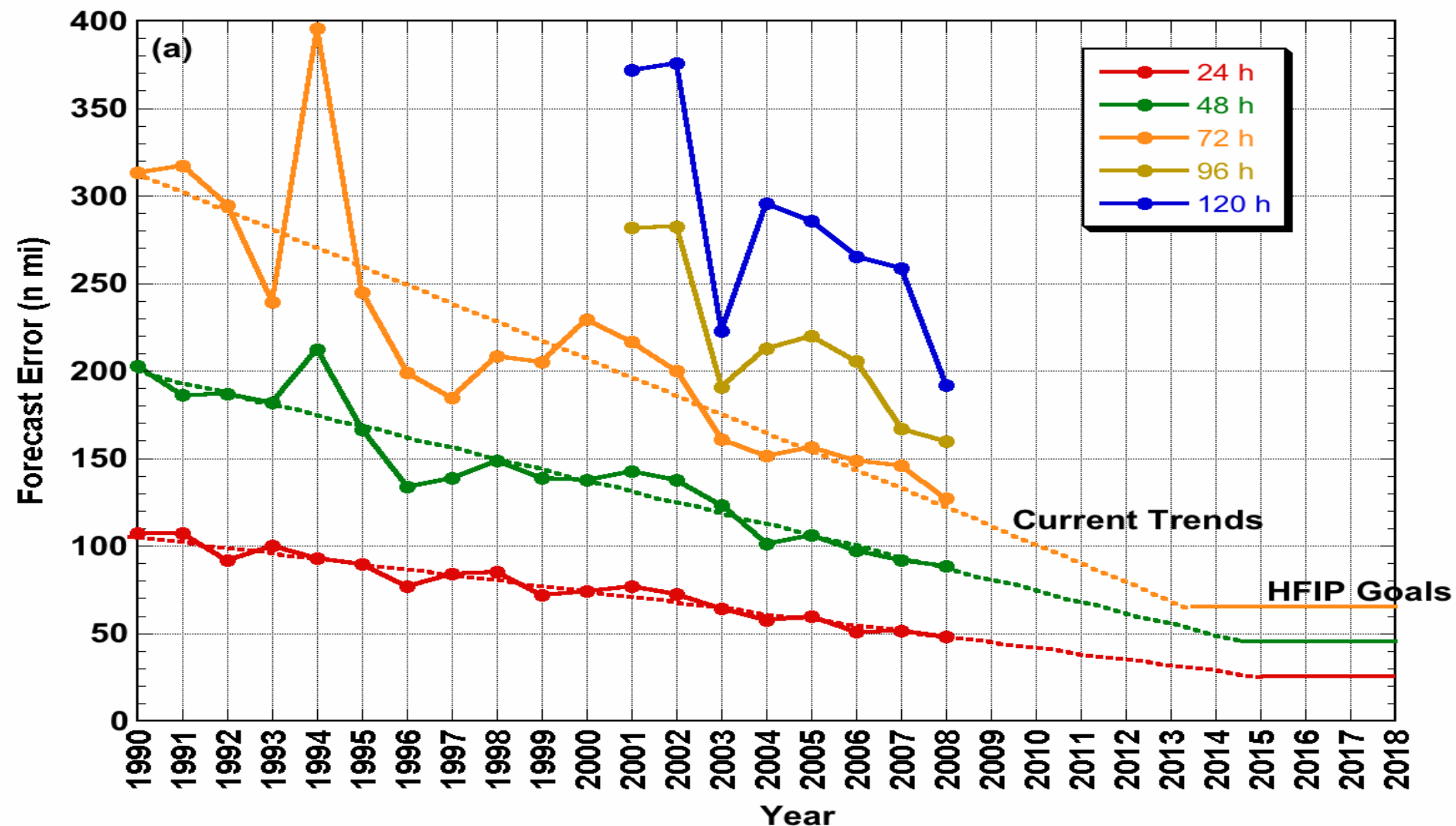
- * Skill in analysis with satellite and aircraft improvements
- * Better models to extract track forecast
- * Computers up to the task
- * Communication explosion...Internet, wireless phone

Key to warning response

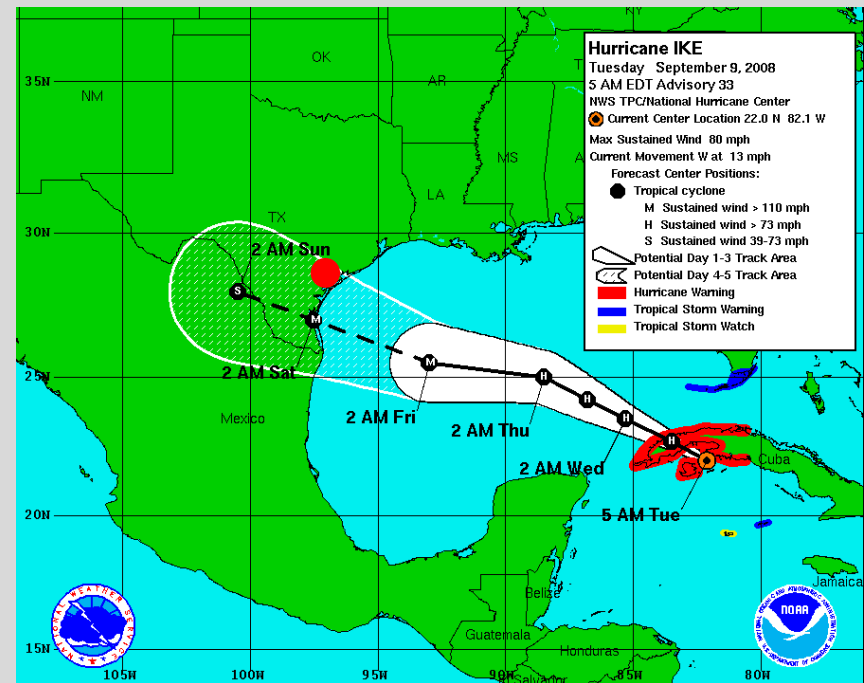
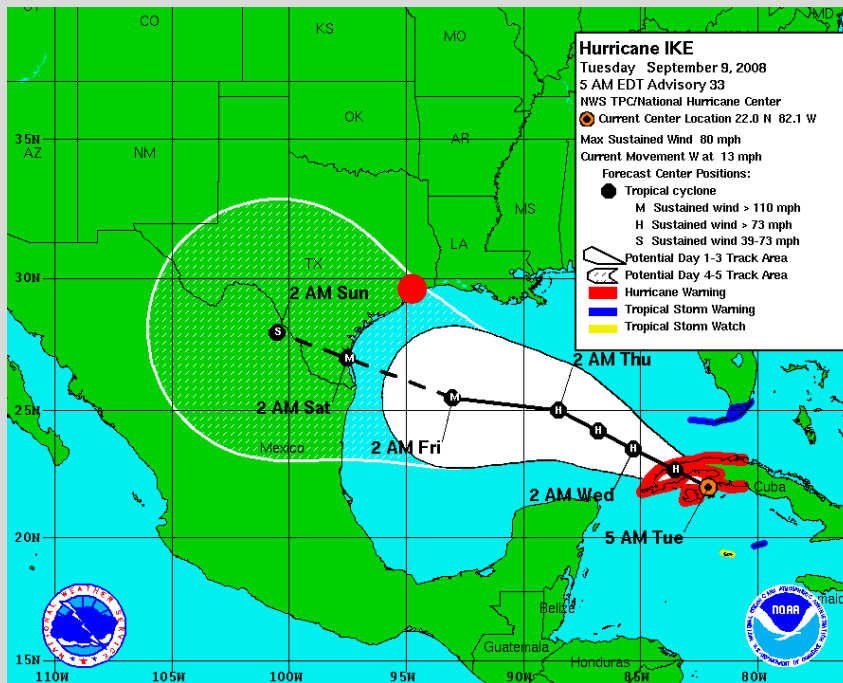
- * Ability to get info directly – internet, what follows are quickly assimilated into society (note Central America since Mitch 1998)
- * Personalize the threat – what's it mean to me?
- * How to clearly convey what is meant
- * Uncertainty – big nut to crack

Track improvement trend and HFIP

Goals – Limit to predictability?

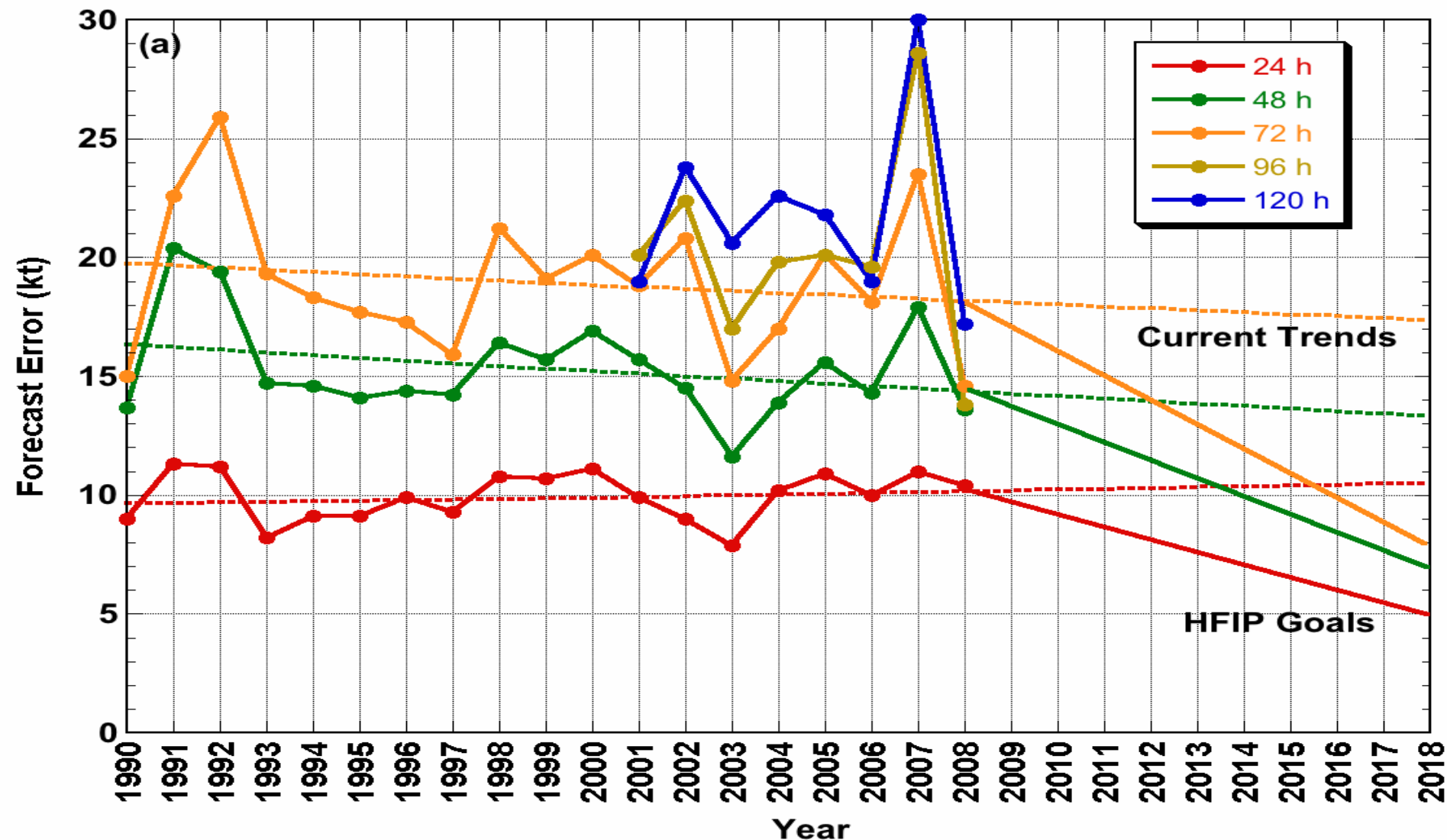


Ike example with current and future cone (HFIP Goal)



- Red dot is landfall - Same relative error to cone – note much smaller threat area

Intensity Goals for HFIP much more of a challenge than Track



**“Forecasting can be very
difficult --- particularly
when it involves the
future.”**

Yogi Berra

Any Questions?



AP

* Hurricane Liaison Team Brief as Ike made landfall