Introduction to the NHC Forecast Process

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National Hurricane Center

National Hurricane Conference
L311 – Hurricane Readiness for Coastal Communities
New Orleans, Louisiana
25 March 2013

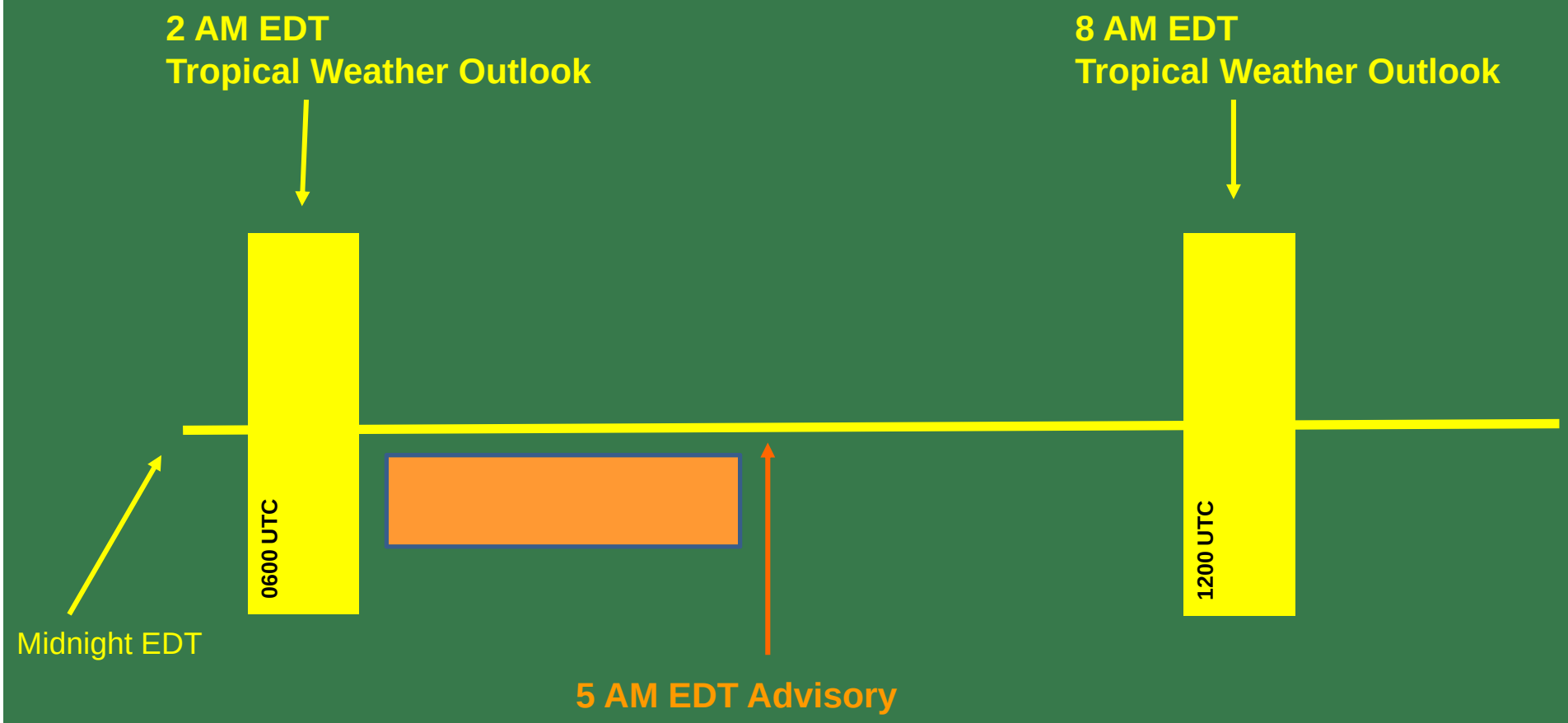
NHC Six-Hour Forecast Cycle

Time (HR : MIN)	Event
00:00	**Issue Tropical Weather Outlook** **Issue Intermediate Public Advisory (if necessary)** **Synoptic time / cycle begins**
00:45	**Receive satellite fix data**
01:00	**Initialize models**
01:10	**Receive model guidance and *prepare forecast***
02:00	**NWS / DOD hotline coordination**
03:00	**Advisory deadline**
03:15	**FEMA conference call**
06:00	**New cycle begins**

Why are advisories issued at 5 am, 11 am, 5 pm, and 11 pm EDT?

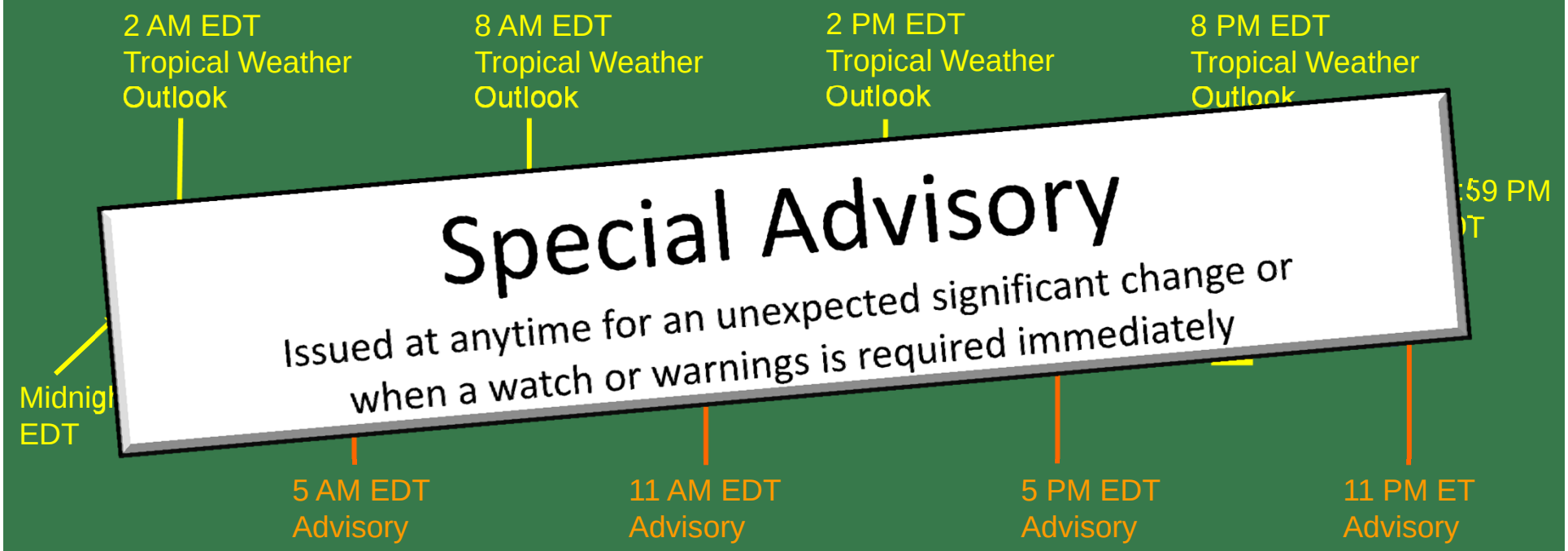
- Advisory cycle tied to UTC or "Z" time
- Synoptic times- 0000, 0600, 1200, and 1800 UTC.
  - Additional surface and ship data available at these times.
  - Upper-air observations (balloon launches) occur around 0000 and 1200 UTC.
- Synoptic times are the starting points or initial times of the forecasts
- Approximately 3 hours is needed to compose and coordinate the forecast package
  - This was reduced by an hour in the 1980s.

Timeline of NHC Tropical Cyclone Advisories and Tropical Weather Outlooks



= Advisory Preparation Time

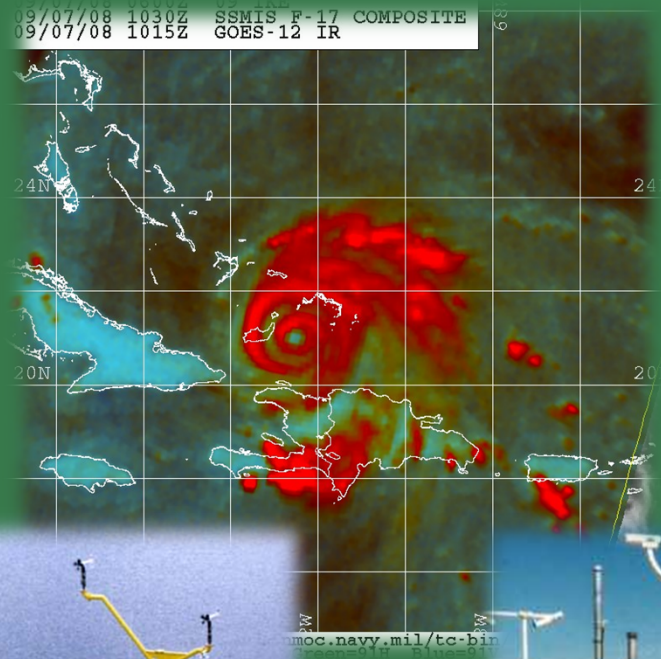
Timeline of NHC Tropical Cyclone Advisories and Tropical Weather Outlooks

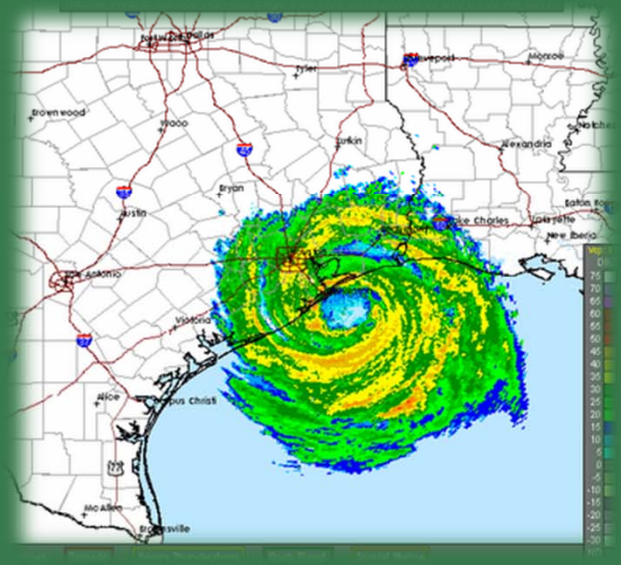


= Advisory Preparation Time

00:00 Synoptic time / cycle begins

Hurricane specialist analyzes available observations



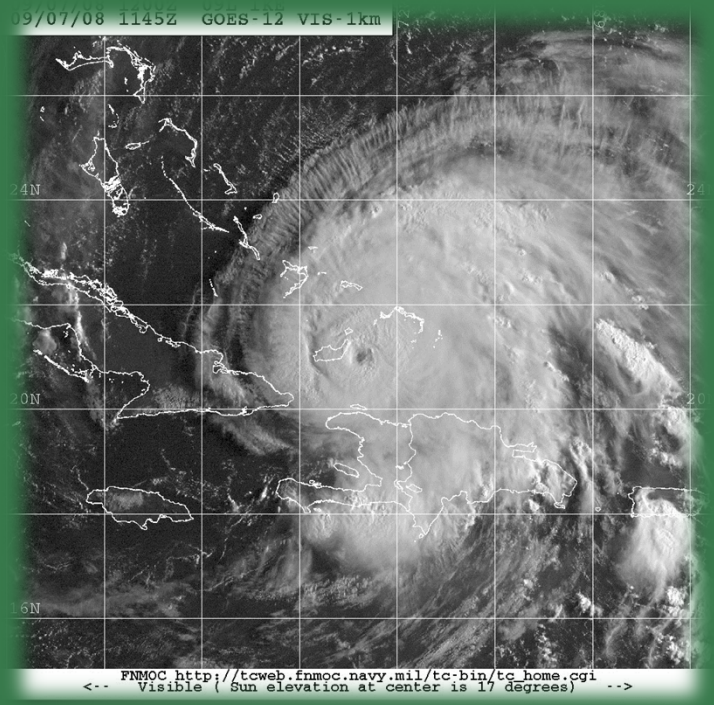


Questions the forecaster must first answer…

1. Where is the storm located?
   - Latitude/Longitude
   - From this motion can be determined

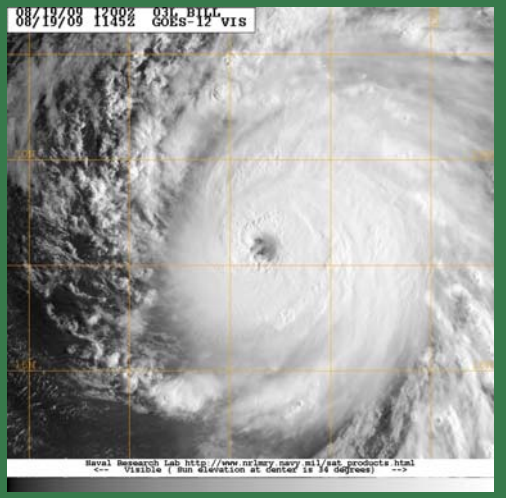
2. How strong is the storm?
   - Maximum sustained winds

3. How big is the storm?
   - Extent of tropical-storm and hurricane-force winds



Data Sources Used in Tropical Cyclone Analysis
…to answer the questions

- Geostationary Satellites
  - Help determine center location (with varying degrees of confidence)
  - Apply Dvorak technique to imagery to estimate a system's intensity
  - Allows forecasters to see features that might influence the future track/intensity

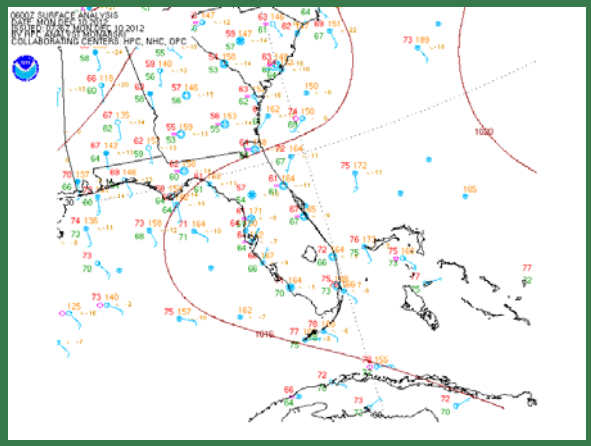


- Low-Earth Orbiting Satellites
  - Can be used to look at storm structure
  - Other instruments can provide intensity estimates

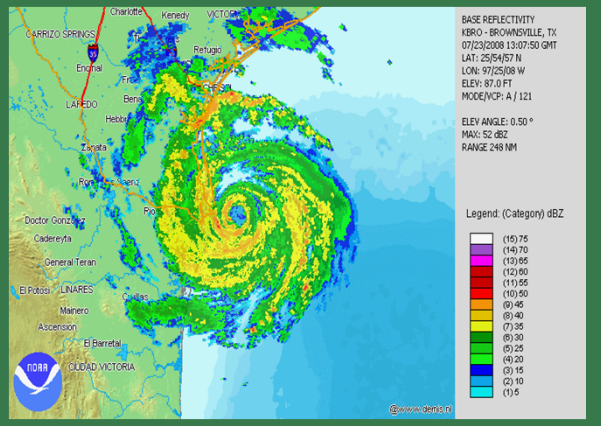
- Reconnaissance Aircraft
  - Flight-level winds
  - Dropwindsonde Data
  - Surface wind data from the SFMR

Other Important Data Sources Used in Tropical Cyclone Analysis

- Surface observations
  - Ship and buoy reports
  - Land based observing sites



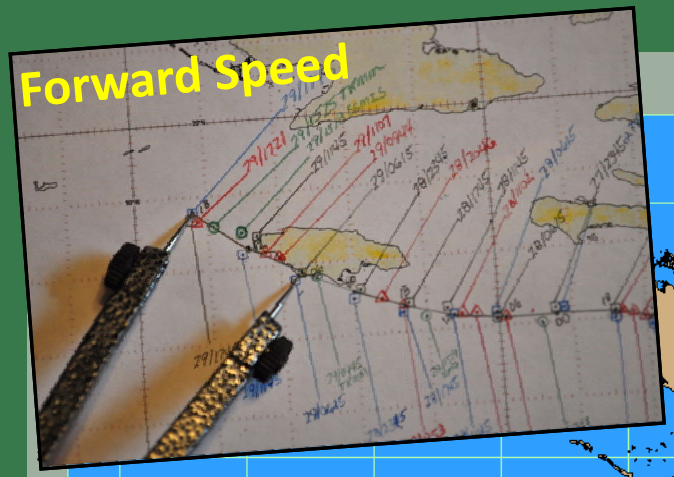
- Radar
  - Provides rain distribution and wind (Doppler) information
  - Useful for “now-casting” during an event and a few hours prior) but little forecast utility

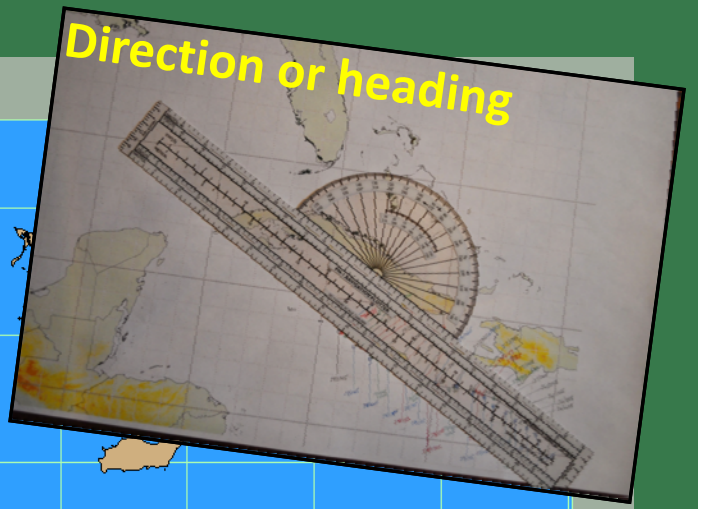


Sounds like a lot of data but…

Only a tiny fraction of the storm circulation is sampled and the chances of encountering the storm’s peak winds are very small.

Step 1- Determining Initial Location





al792010 - AMS

29/1525 TRMM

29/1318 SSMIS

29/1745

29/1745

29/1721

2912Z 8 50

2906Z 7 50

2900Z 7 55

2818Z 7 50

2812Z 7 45

2806Z 7 45

2800Z 8 40

2718Z 5 40

2712Z 5 30

20N
19N
18N
17N
16N

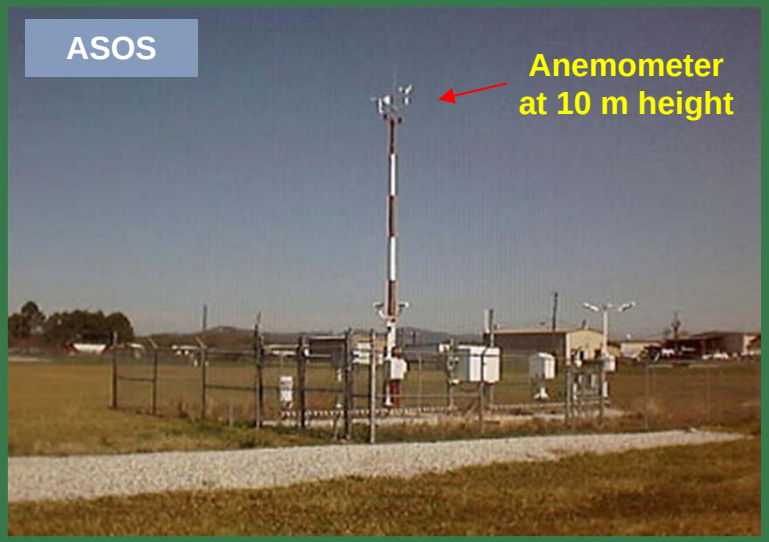
83W 82W 81W 80W 79W 78W 77W 76W 75W 74W 73W 72W 71W 70W

Center Location

ATCF SIMULATOR

Step 2- Determining the Intensity

What do we mean by maximum sustained winds?

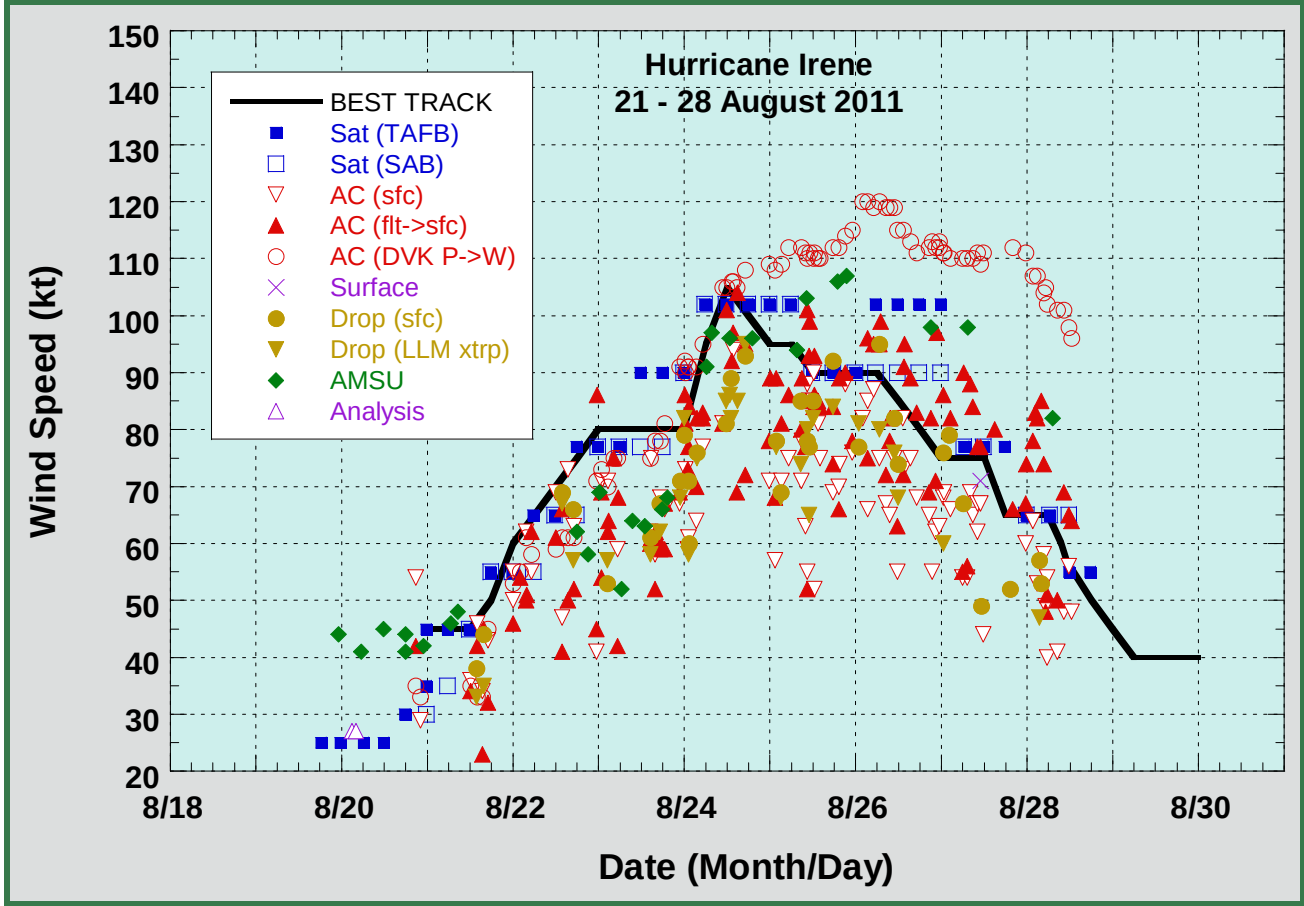


Maximum sustained winds:

Strongest wind speed *averaged during a 1-minute period* at an altitude of *10 m (33 ft)*, associated with the circulation of the tropical cyclone at a given point in time

- Central pressure is correlated with intensity, but pressure-wind relationship has variability
- Max. wind speed usually estimated, rarely directly measured
- NHC initial intensity estimates are believe to be good to within about 10 %
  - 100 mph storm could be 90 mph or 110 mph

Dealing with Conflicting Intensity Estimates



Irene's intensity (black) and intensity estimates the forecaster receives

HURRICANE IRENE DISCUSSION NUMBER 24
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL092011
500 AM EDT FRI AUG 26 2011

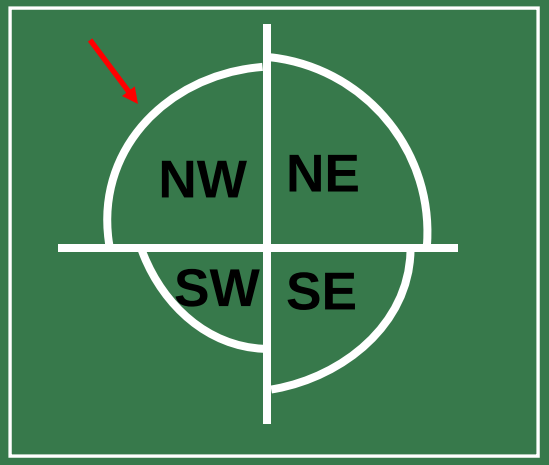
THE MAXIMUM FLIGHT-LEVEL WINDS AT 700 MB WERE **109 KT** ABOUT 75 N MI EAST-NORTHEAST OF THE CENTER...AND THE MAXIMUM SURFACE WINDS REPORTED FROM THE STEPPED FREQUENCY MICROWAVE RADIOMETER WERE **87 KT**. BASED ON THESE DATA...**THE INTENSITY ESTIMATE IS REDUCED TO 95 KT...WHICH IS ALSO BETWEEN THE SATELLITE INTENSITY ESTIMATES OF 102 KT FROM TAFB ANND 90 KT FROM SAB.** THE AIRCRAFT DATA INDICATE THAT A 20 N MI WIDE EYE IS PRESENT AND THAT THE CENTRAL PRESSURE REMAINS NEAR 942 MB.

NHC Discussion mentions the compromise

Step 3- How big is the storm?

Tropical Cyclone Wind Radii

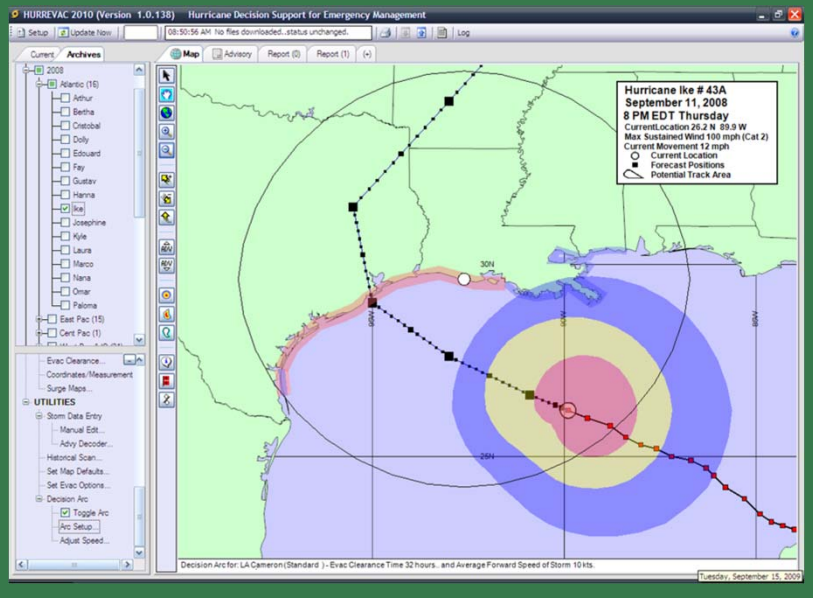
radii represent the largest distance from center in particular quadrant



leads to an inherent over-estimate of radii, especially near land

-NHC estimates cyclone "size" via wind radii in four quadrants

•Wind radius = Largest distance from the center of the tropical cyclone of a particular sustained surface wind speed threshold (e.g., 34, 50, 64 kt) somewhere in a particular quadrant (NE, SE, SW, NW) surrounding the center and associated with the circulation at a given point in time

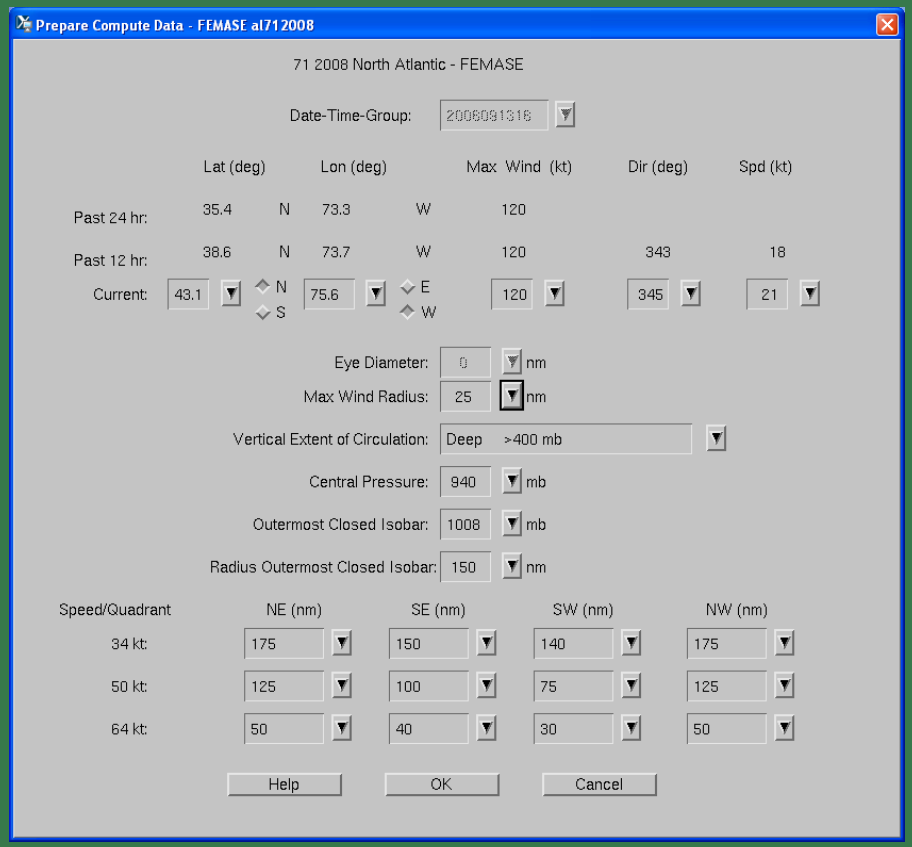


Wind radii in Hurrevac

Initialize models

After determining the center, strength, motion, and size of the tropical cyclone, the hurricane specialist gives that information to a supercomputer to run the models

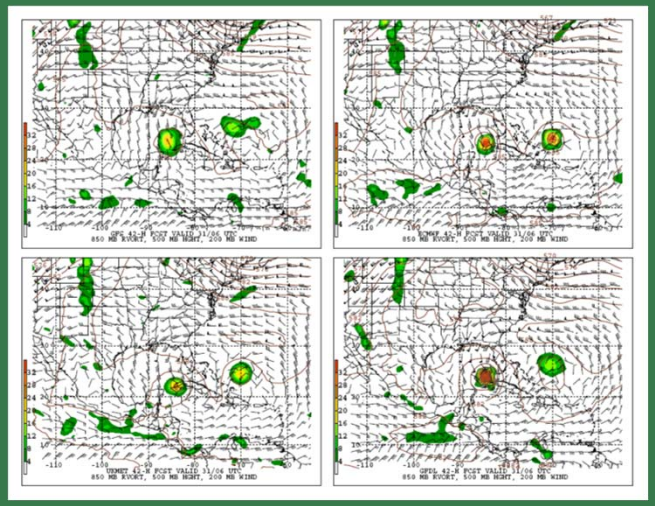
- Initialize computer models

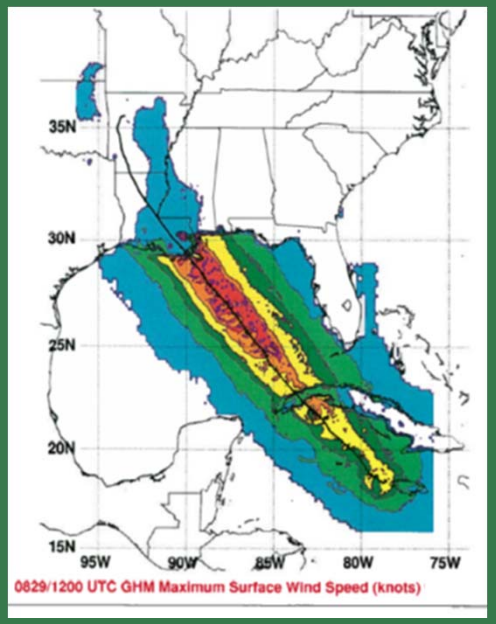


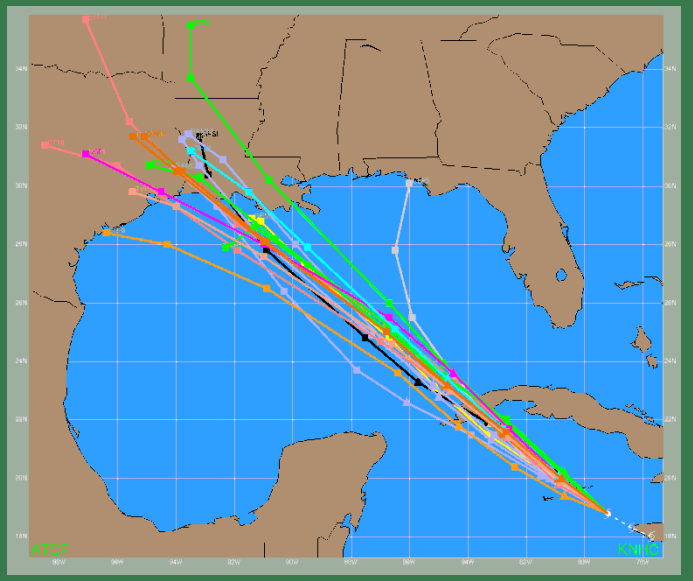
1:10

Receive model guidance and prepare forecast

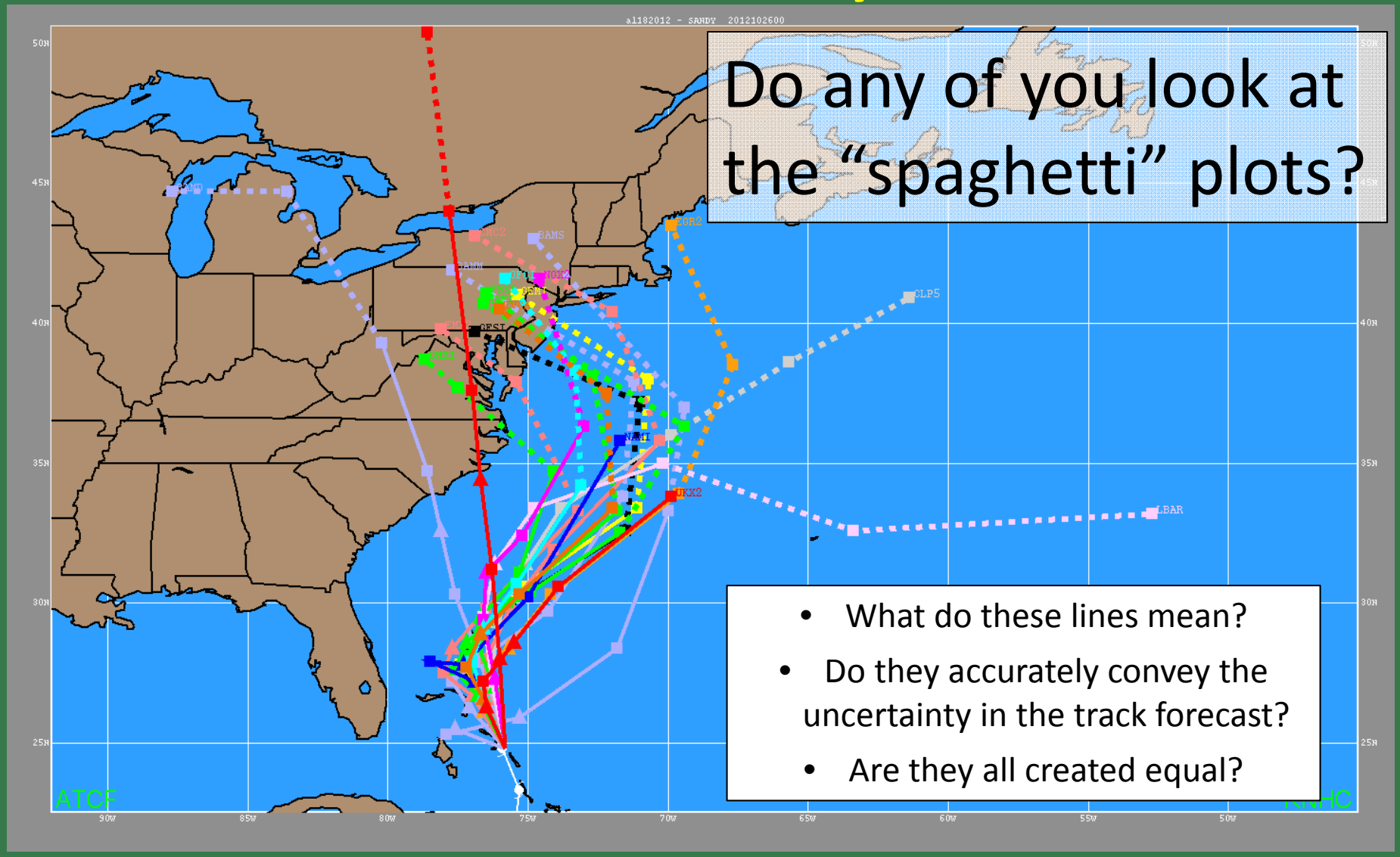
- Analyze and QC computer models
- Prepare track, intensity, and wind radii forecasts





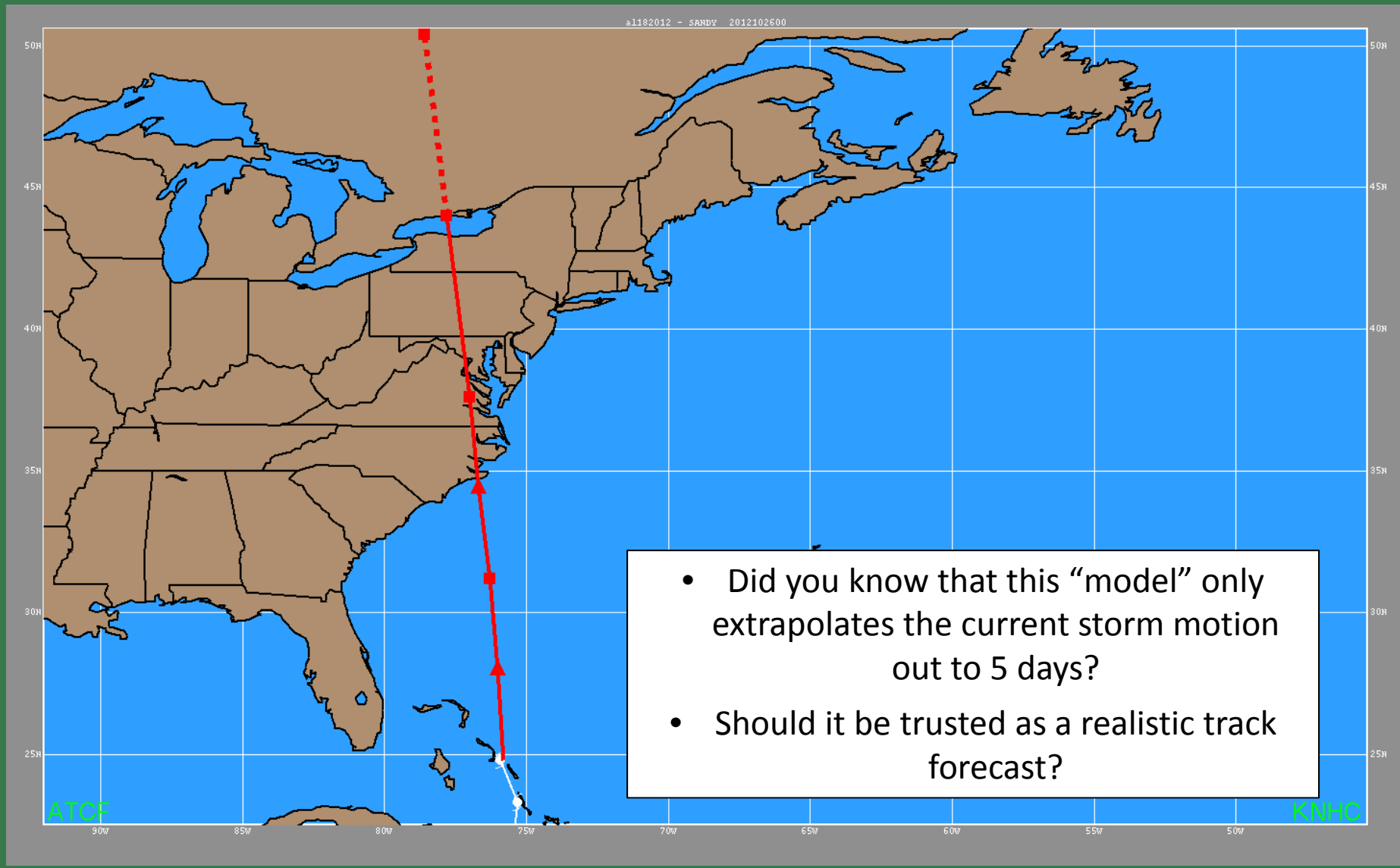


Computer Models are the Basis of NHC Track and Intensity Forecasts



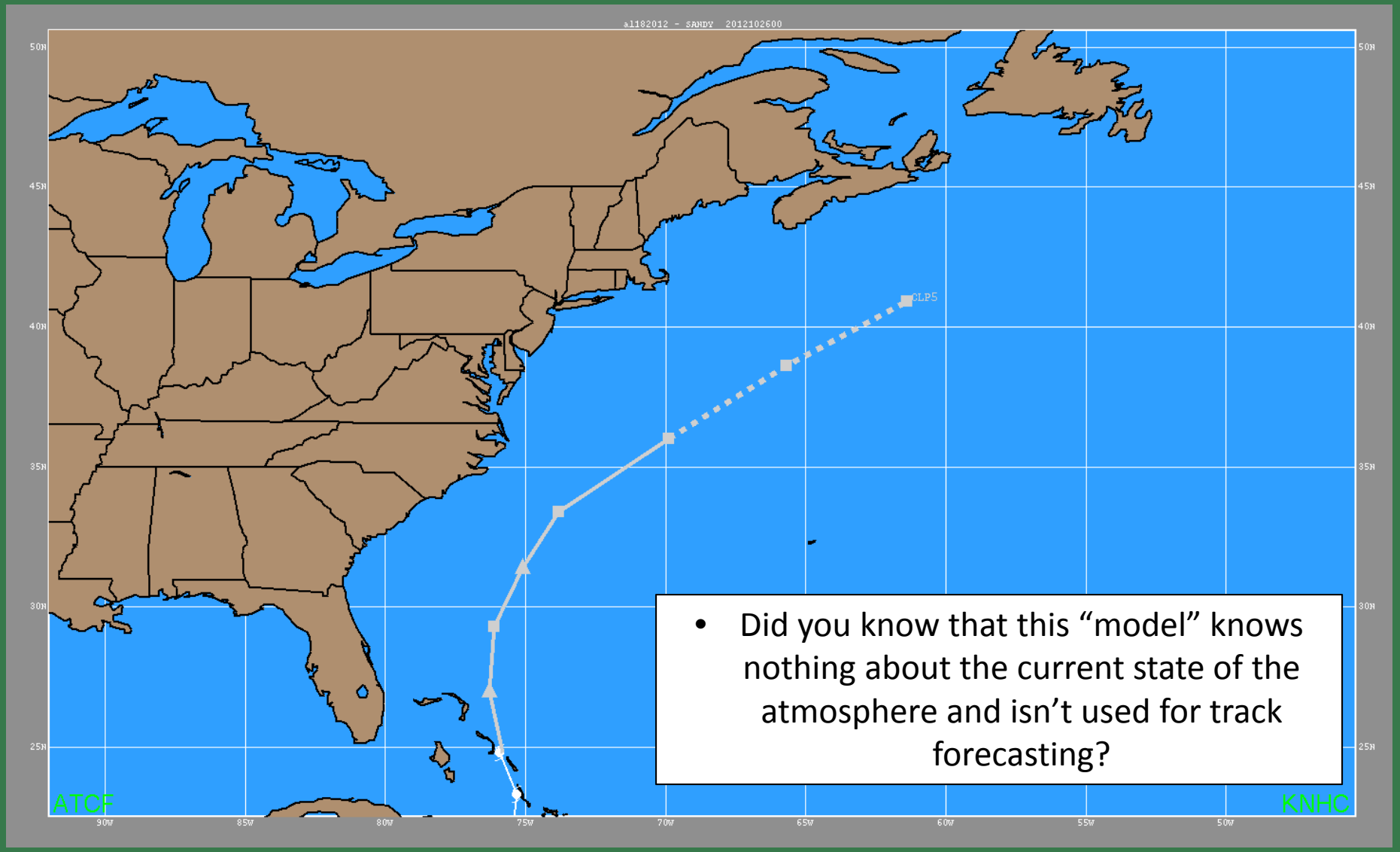
- What do these lines mean?
- Do they accurately convey the uncertainty in the track forecast?
- Are they all created equal?

Model Plots



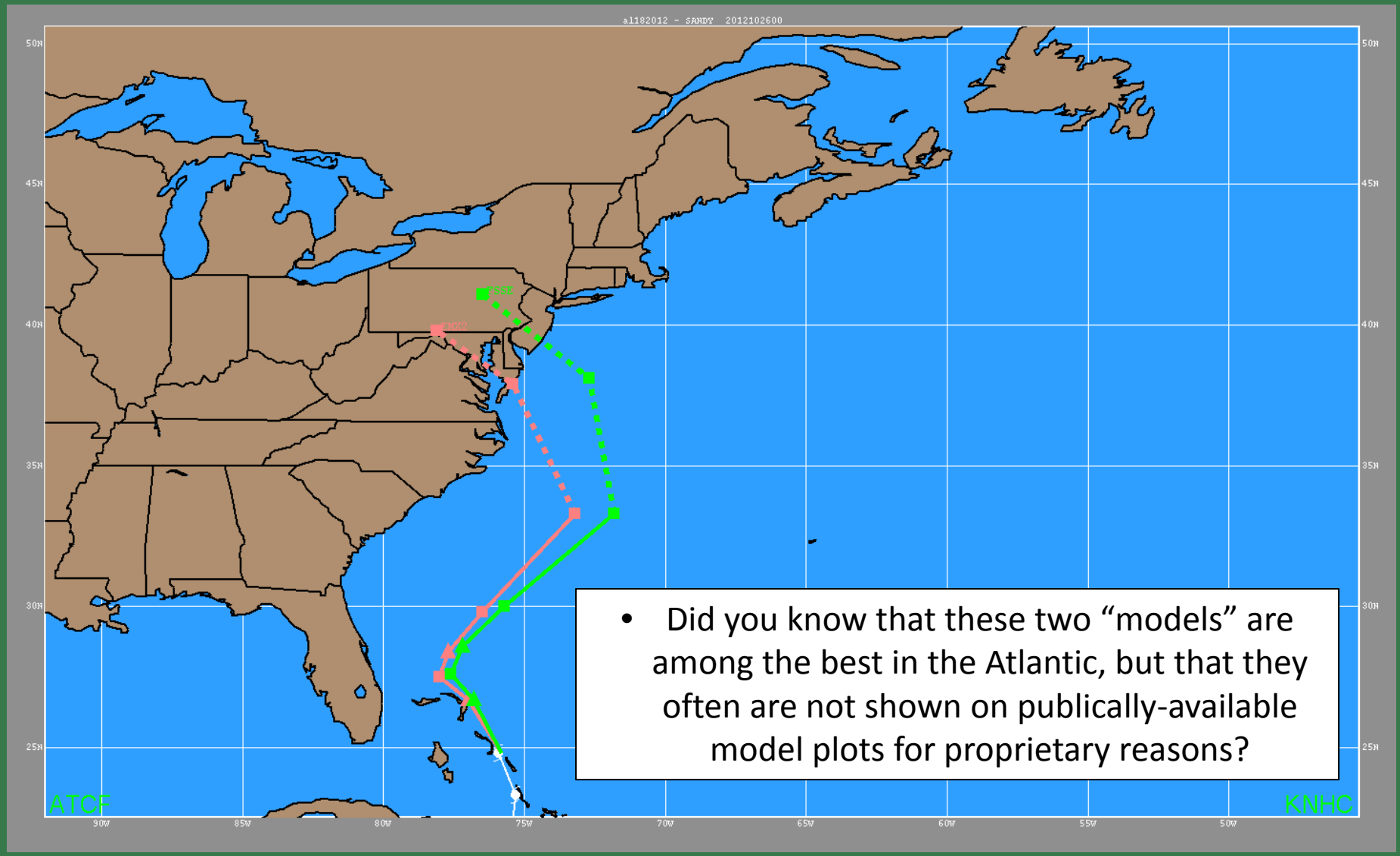
- Did you know that this “model” only extrapolates the current storm motion out to 5 days?
- Should it be trusted as a realistic track forecast?

Model Plots



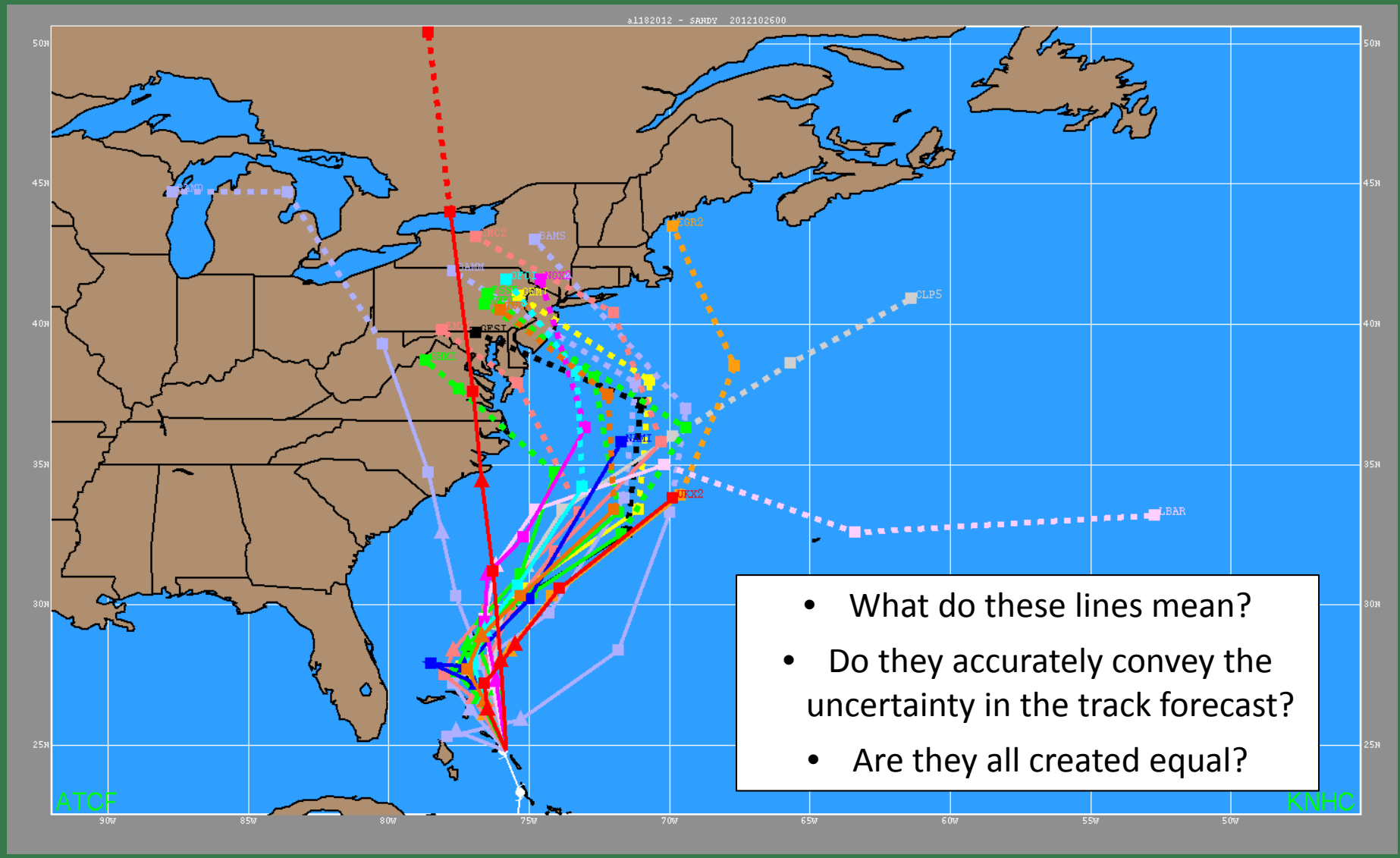
- Did you know that this “model” knows nothing about the current state of the atmosphere and isn’t used for track forecasting?

Model Plots



- Did you know that these two “models” are among the best in the Atlantic, but that they often are not shown on publically-available model plots for proprietary reasons?

Model Plots – Now What?



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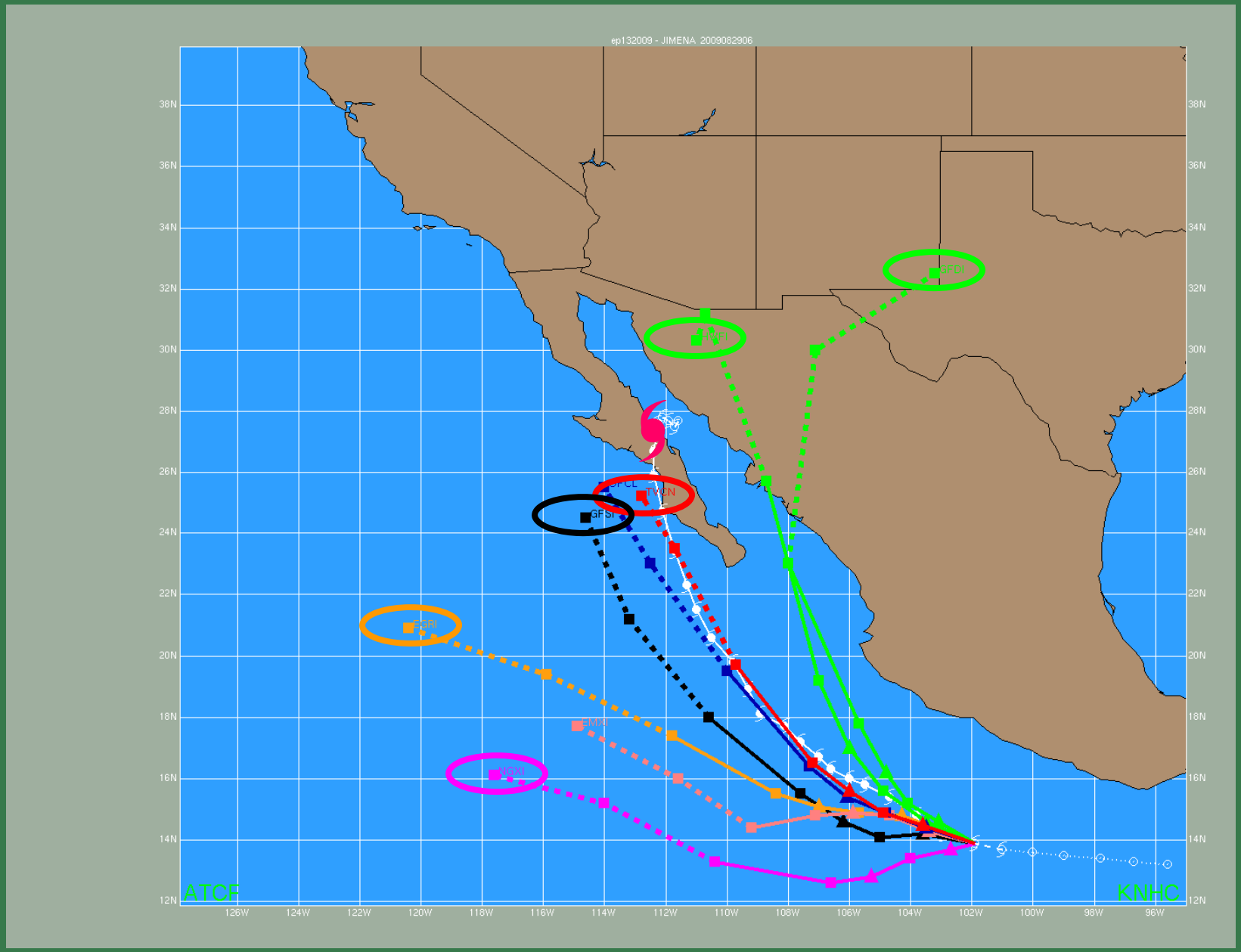
Hierarchy of TC Track Models

- **Statistical**
- *CLIPER (Climatology-Persistence)*
  - Knows NOTHING about current state of atmosphere
- **Simplified Dynamical (Trajectory)**
- *BAMD, BAMM, BAMS*
  - Follow cork in stream analogy, where the cork (the hurricane) is not allowed to have any impact on the stream
- **Dynamical models – General characteristics**
- *GFS, ECMWF, UKMET, GFDL, HWRF, NOGAPS*
  - Most sophisticated models available
  - Solve fundamental physical equations of the atmosphere and include wide range of physical processes

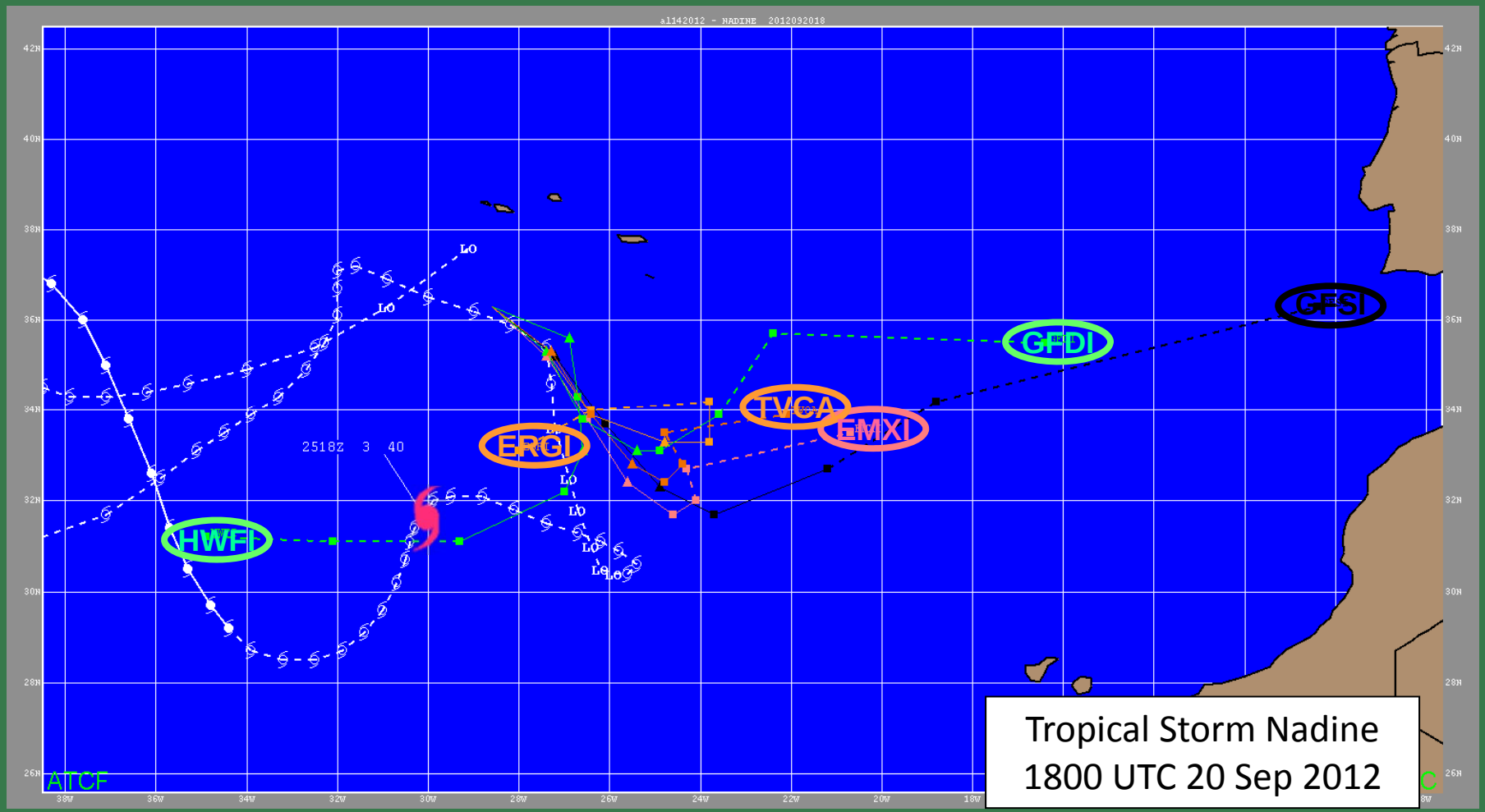
Hierarchy of TC Track Models

- **Consensus**
- *TVCA, TVCE, FSSE*
  - Not actual models, but combinations of other models (two heads are better than one)
    - Can be a simple average (e.g., TVCA is a simple average of GFDL, HWRF, GFDN, ECMWF, UKMET, and GFS)
    - Can be more complicated, where past performance is used to try to come up with an optimal combination and/or to correct model biases ("corrected consensus")
  - Consensus models generally outperform the individual models that make them up

Power of Consensus

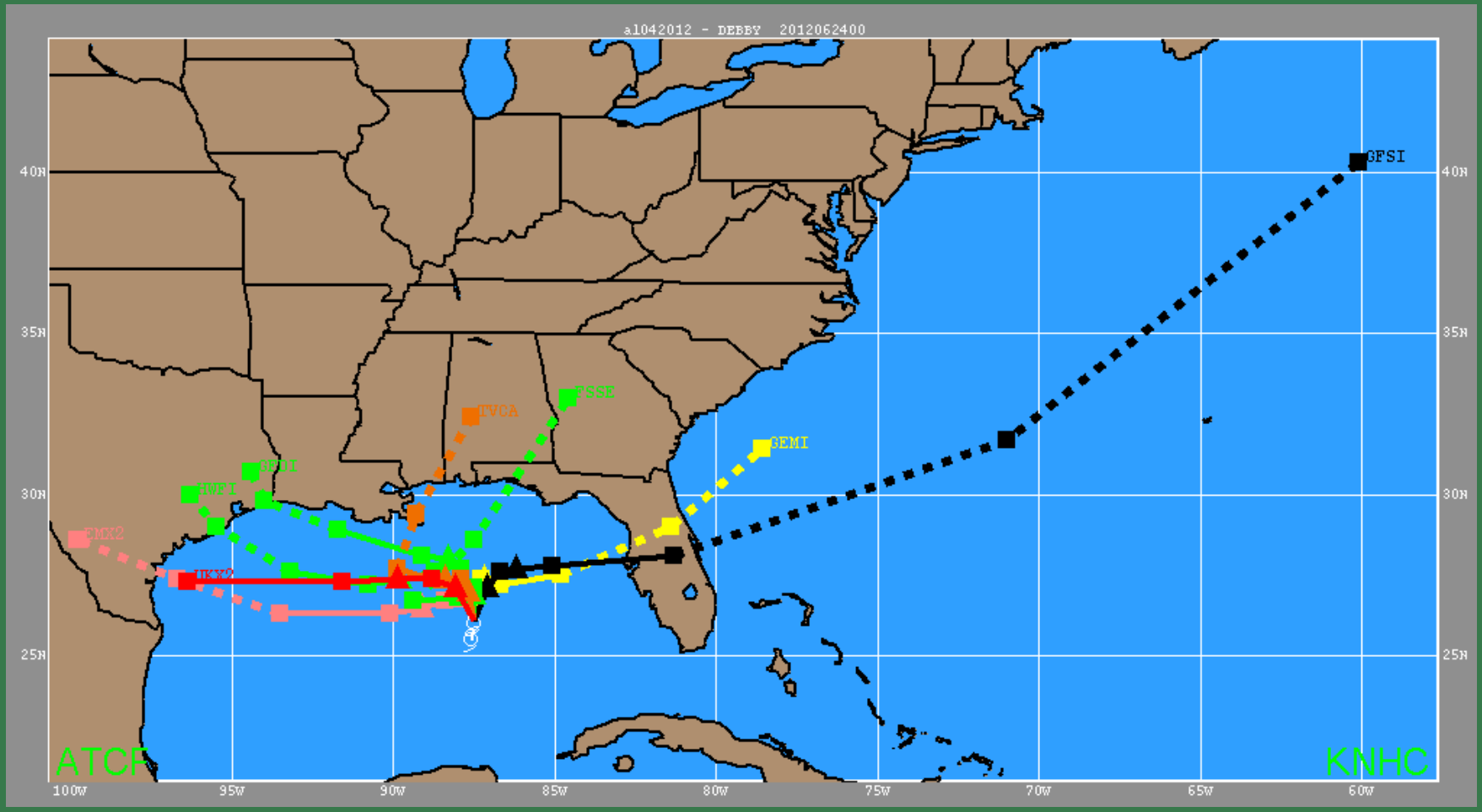


Consensus Example



- Consensus approach doesn't always work, especially when model scenarios are completely different
- Sometimes the forecaster might want to exclude certain models and form a "selective consensus", if the discrepancies among the models can be resolved
- Resolving these discrepancies is very difficult

Consensus Example



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Considerations of Track Forecast

Don't Make Any Sudden Moves!
(unless you really, really have to)

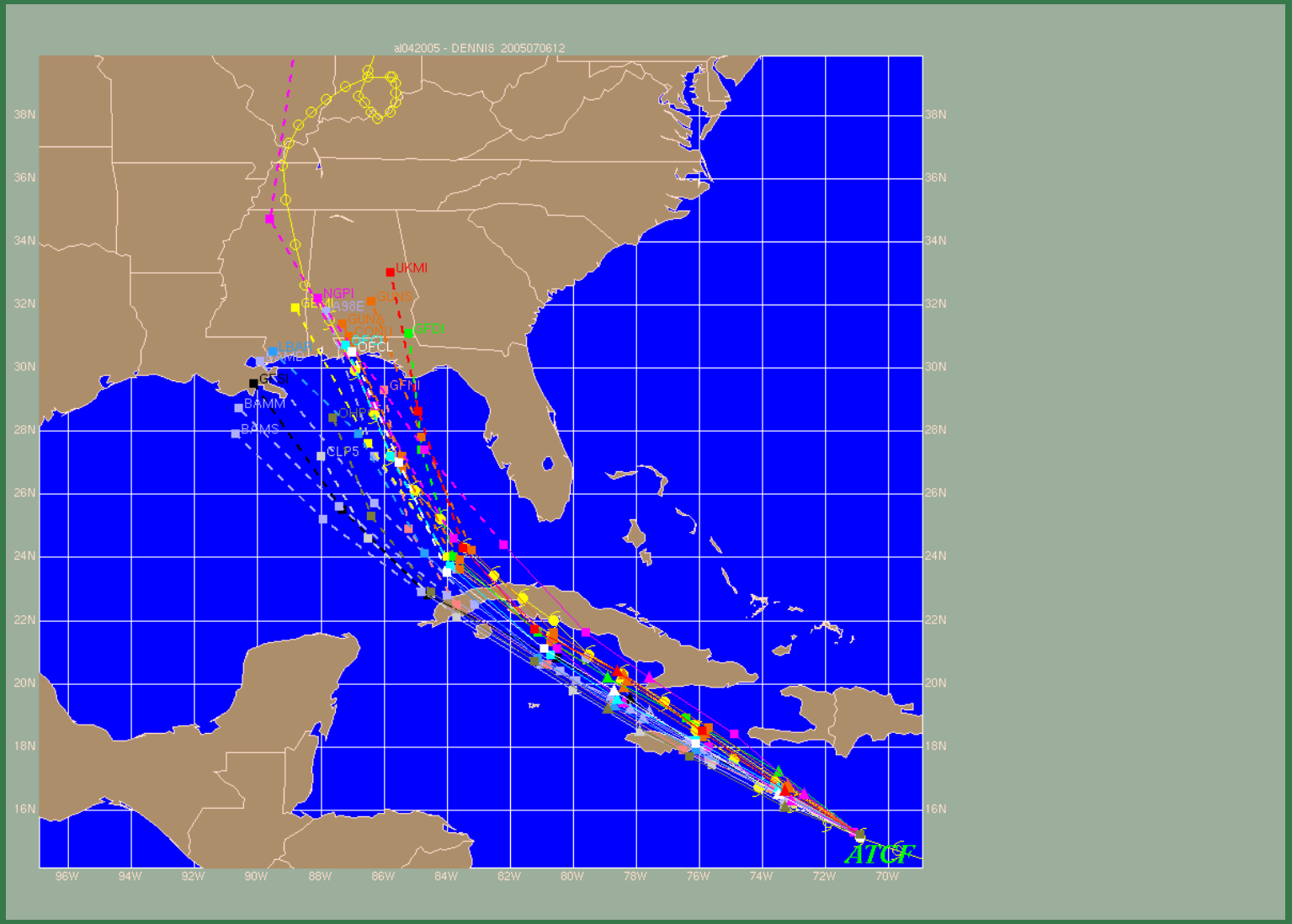
- Previous official forecast exerts a strong constraint on the current forecast
  - Can damage credibility by making big changes from one forecast to the next, and then having to go back to the original

Windshield Wipering

Tromboning

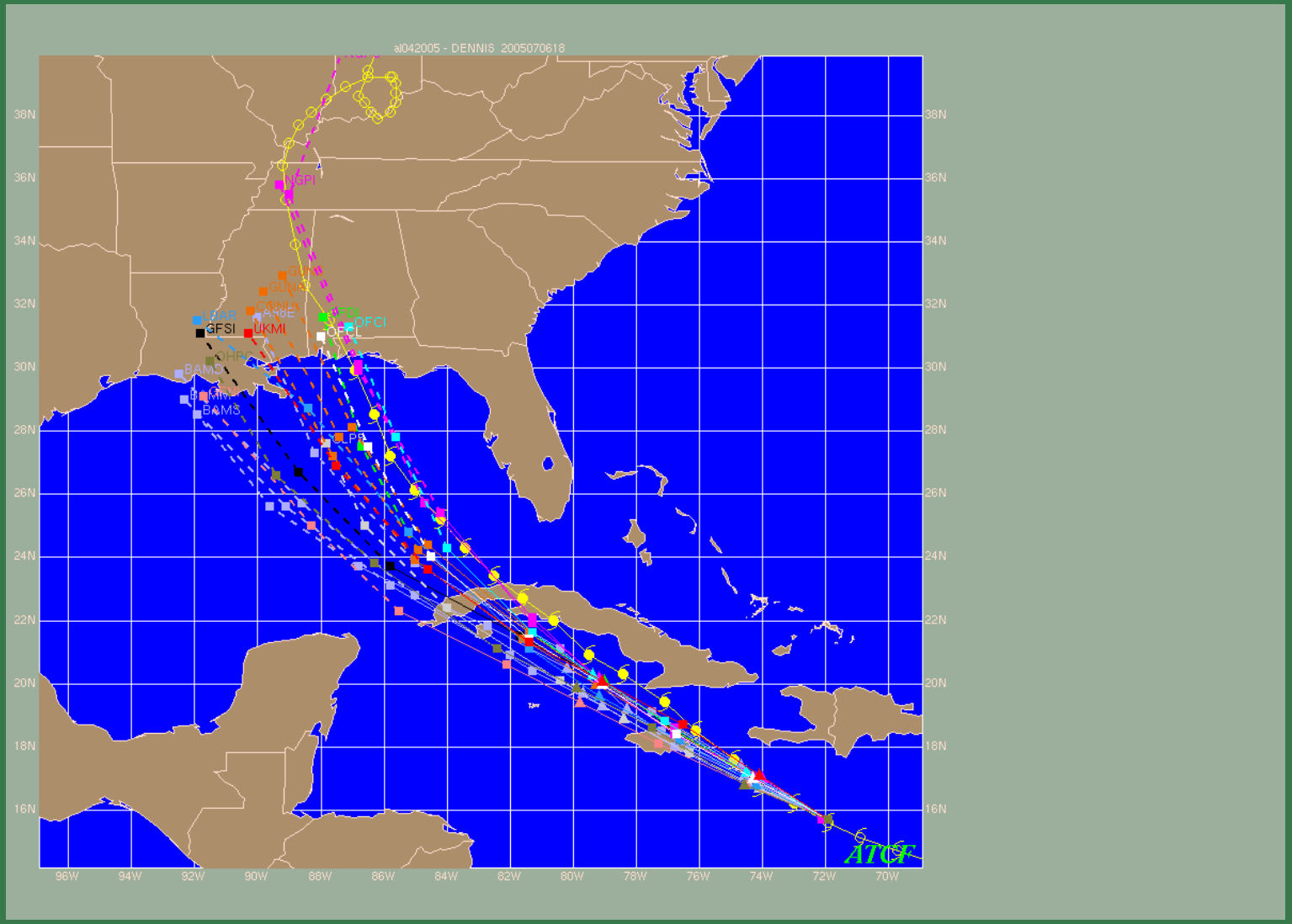
- Consequently, changes to the previous forecast normally made in small increments
- We also strive for continuity within a given forecast
  - Gradual changes in direction or speed from 12 to 24 to 36 h, etc.

Dennis Guidance 6 July 1200 UTC



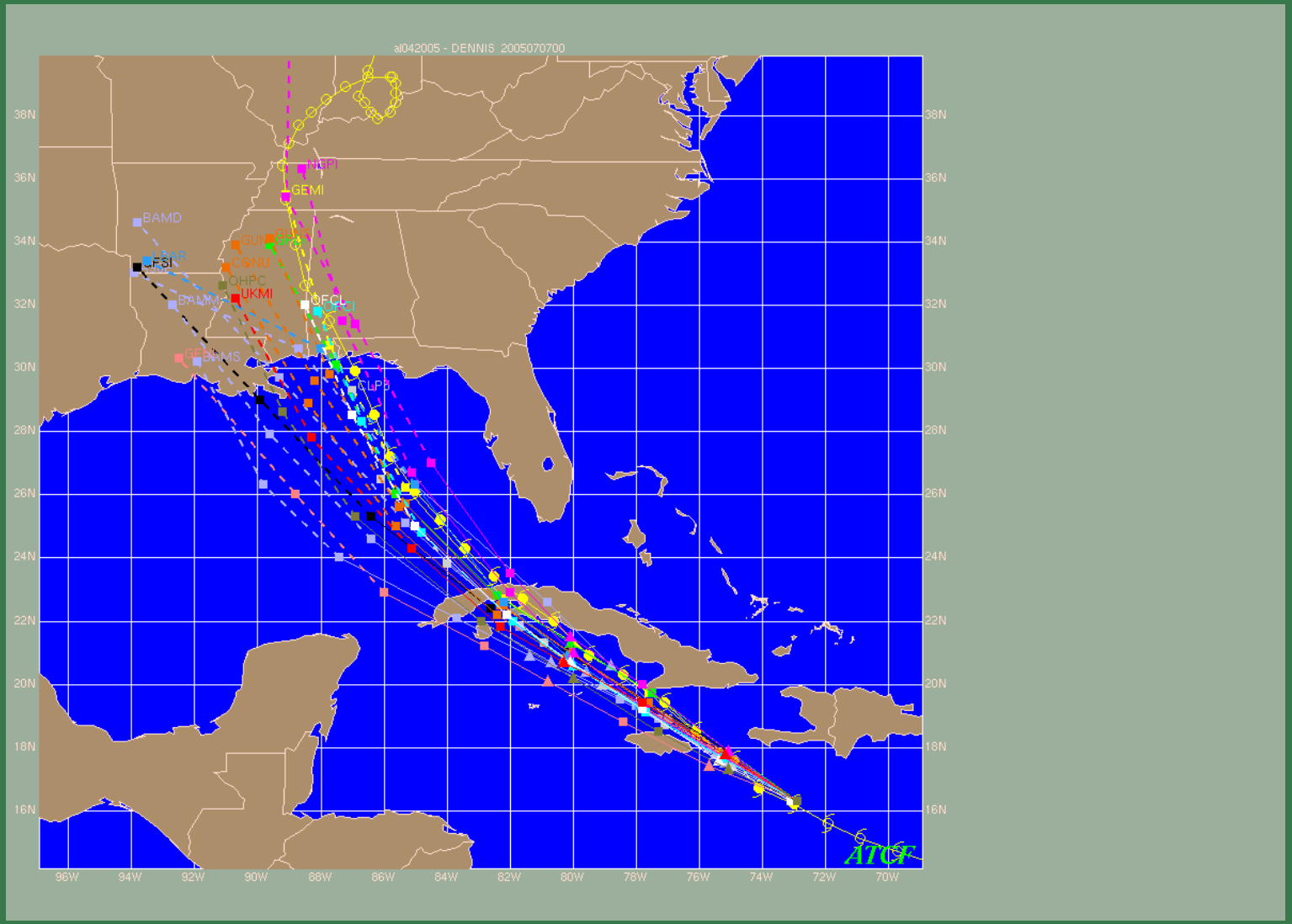
Official forecast near model consensus in extreme western FL panhandle.

Dennis Guidance 6 July 1800 UTC



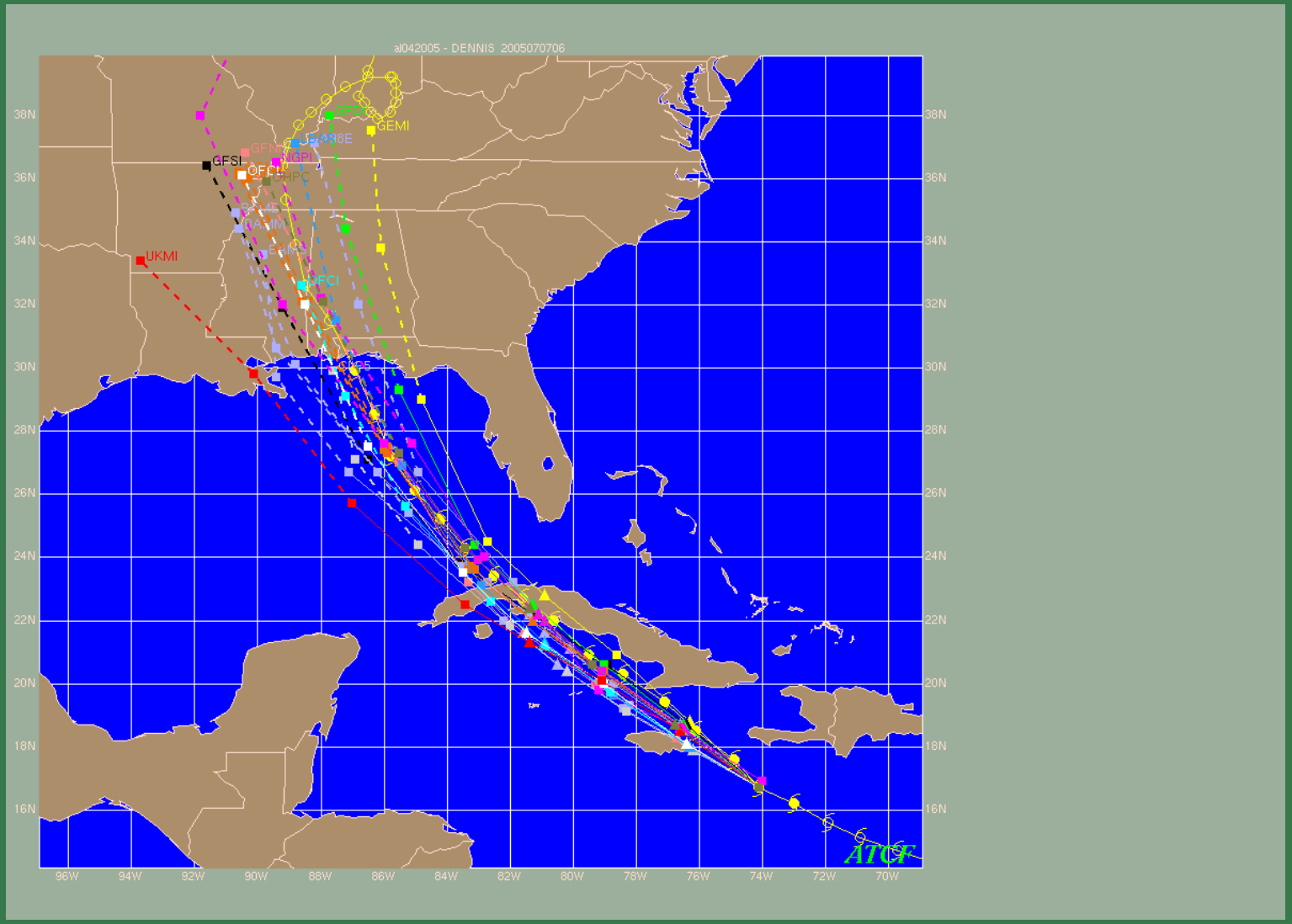
Guidance shifts sharply westward toward New Orleans. Official forecast nudged westward into AL.

Dennis Guidance 7 July 0000 UTC



Little overall change to guidance, but NGPI shifts slightly eastward.
Little change in official forecast.

Dennis Guidance 7 July 0600 UTC



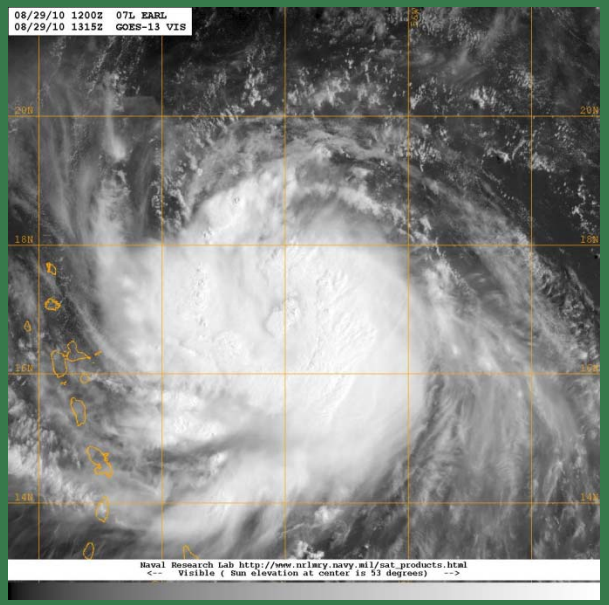
Rest of the guidance shifts sharply eastward, leaving official forecast near the center of the guidance envelope (and very close to the actual track of Dennis.

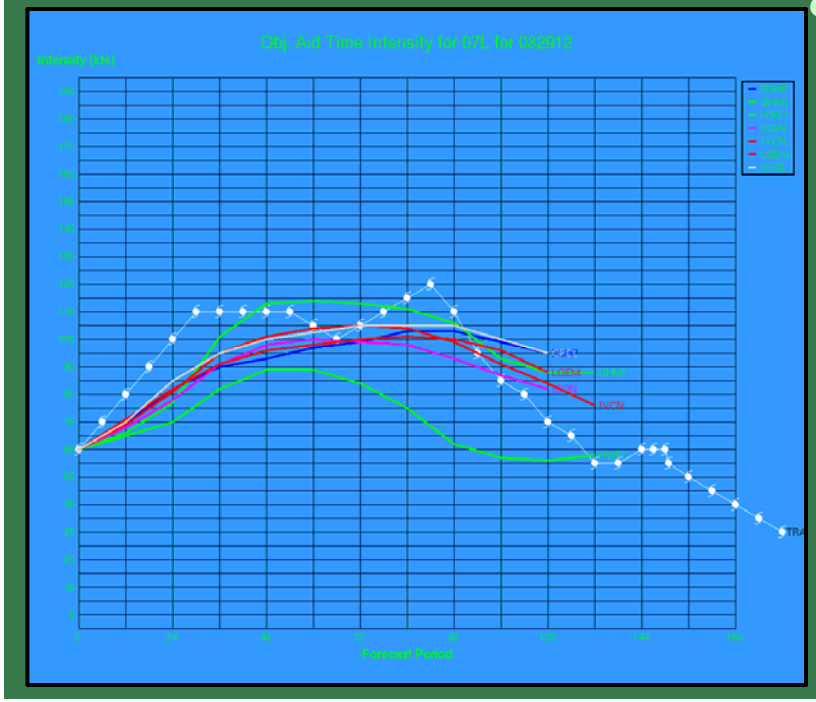
Intensity Forecasting

More complex multi-scale problem

- Intensity Guidance:
  - Statistical (SHIPS/LGEM) and Dynamical (GFLD/HWRF) models
  - Consensus (ICON and FSSE) models
- Intensity forecasting more difficult than track forecasting
- Best intensity models are statistical, which do not predict rapid changes very well
- Dynamical models can predict rapid intensity changes, but not reliably

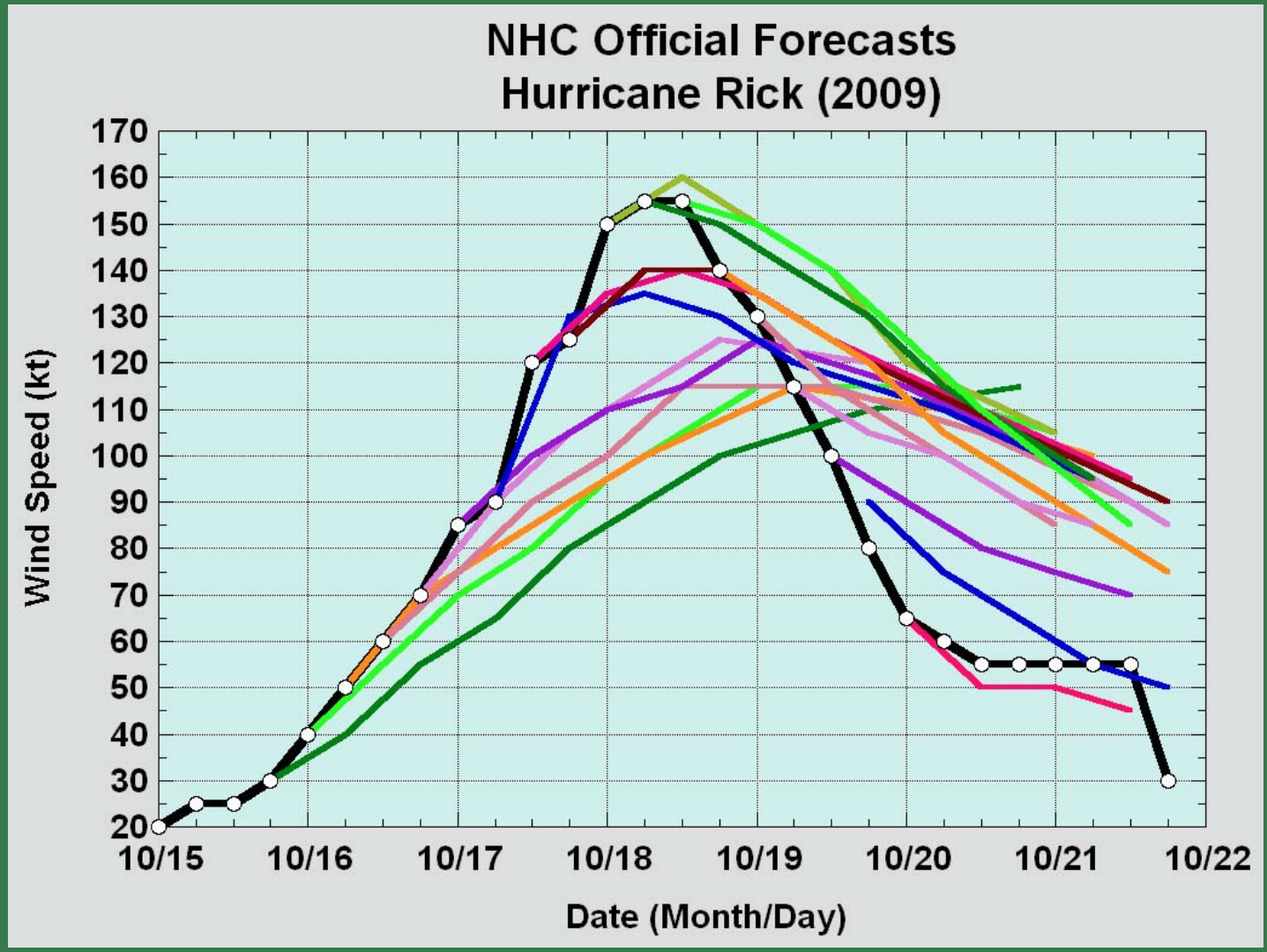
Intensity Forecasting





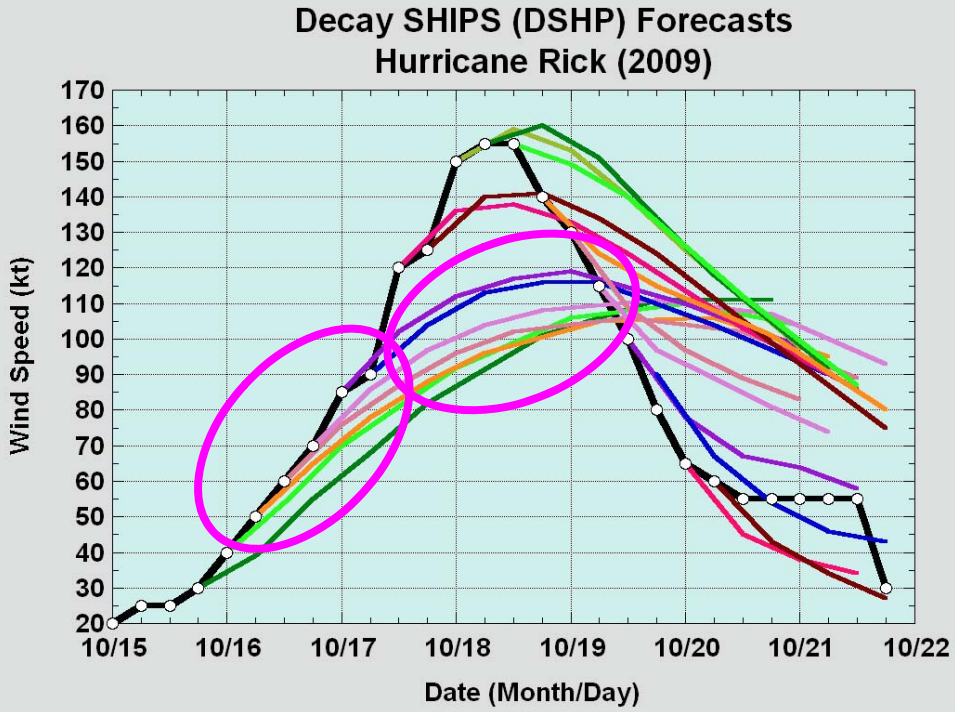
- Similar considerations as for track apply with respect to continuity
- NHC intensity forecasts tend to be conservative; rapid intensity changes are rarely forecast
- Modest changes in track can result in significant differences in SST, vertical wind shear, land interaction, and other environmental factors that affect intensity

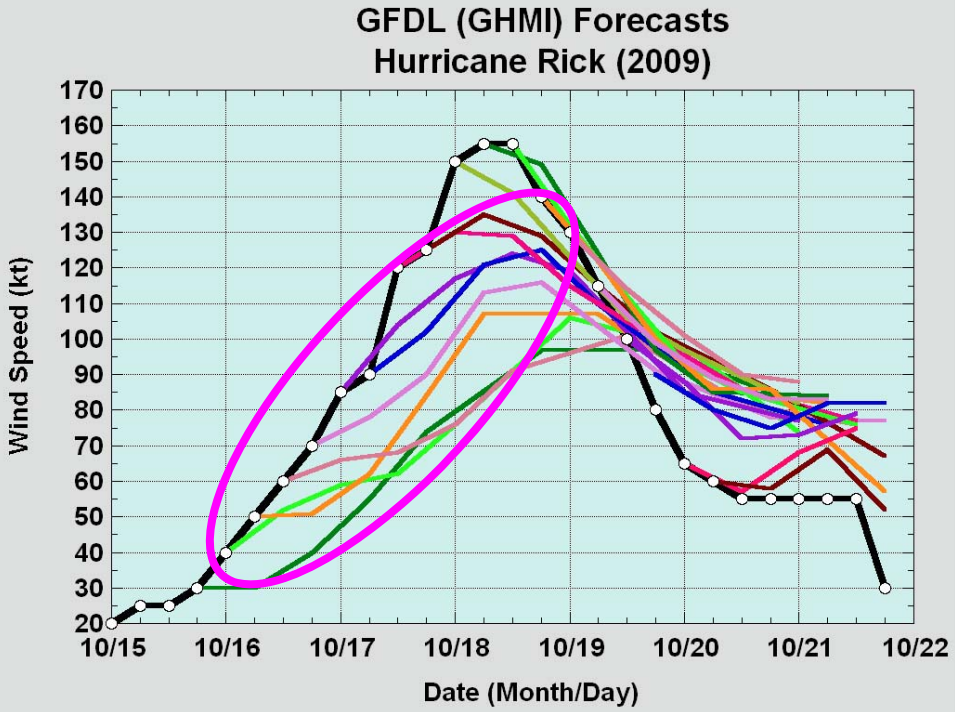
Predicting Rapid Changes in Intensity



Or Not

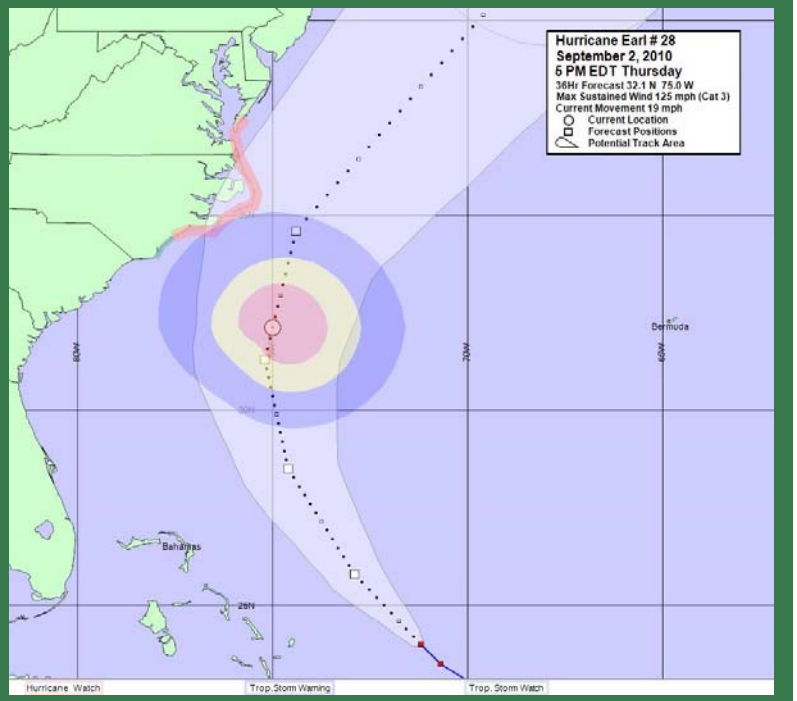
Guidance also has Difficulty Predicting Rapid Changes in Strength





- Decay-SHIPS showed some signal for first period of rapid intensification but badly under-forecast later intensification to cat 4/5
- GFDL can forecast more variability, but suffered from a low bias throughout Rick's life

Wind Radii (Size) Forecasting



- Very little guidance available
  - essentially limited to climatology and persistence models

- Empirical ideas
  - Is the storm strengthening or weakening?
  - Is persistence appropriate, or are conditions changing?
  - Is the storm becoming extratropical, causing the wind field to expand?
  - Will all or part of the circulation be passing over land, such that the radii could decrease?
  - Is the system accelerating, such that the storm could become more asymmetric?

2:00 NWS / DOD Coordination Call

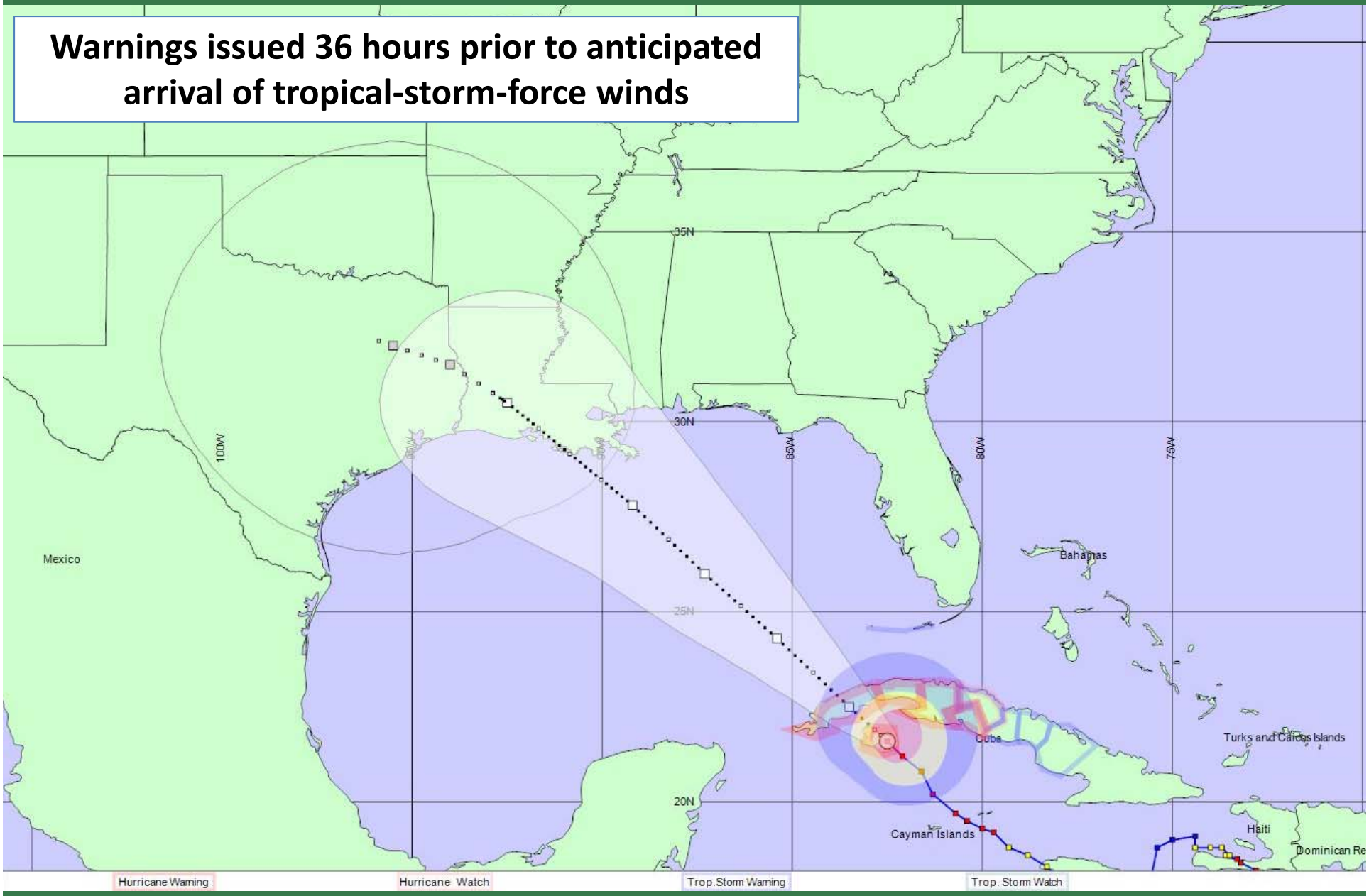
☎ Coordinate and determine watches/ warnings

What do tropical storm and hurricane watches and warnings mean?

- Lead time of tropical storm and hurricane watches and warnings are tied to the anticipated ***arrival time of tropical-storm-force winds***
  - *Watches issued 48 hours prior to arrival of TS winds*
  - *Warnings issued 36 hours prior to arrival of TS winds*
- Watch means that the conditions are ***possible somewhere*** within the watch area
- Warning means that the conditions are ***expected somewhere*** within the warning area

Issuing Warnings

Warnings issued 36 hours prior to anticipated arrival of tropical-storm-force winds



Issuing Warnings

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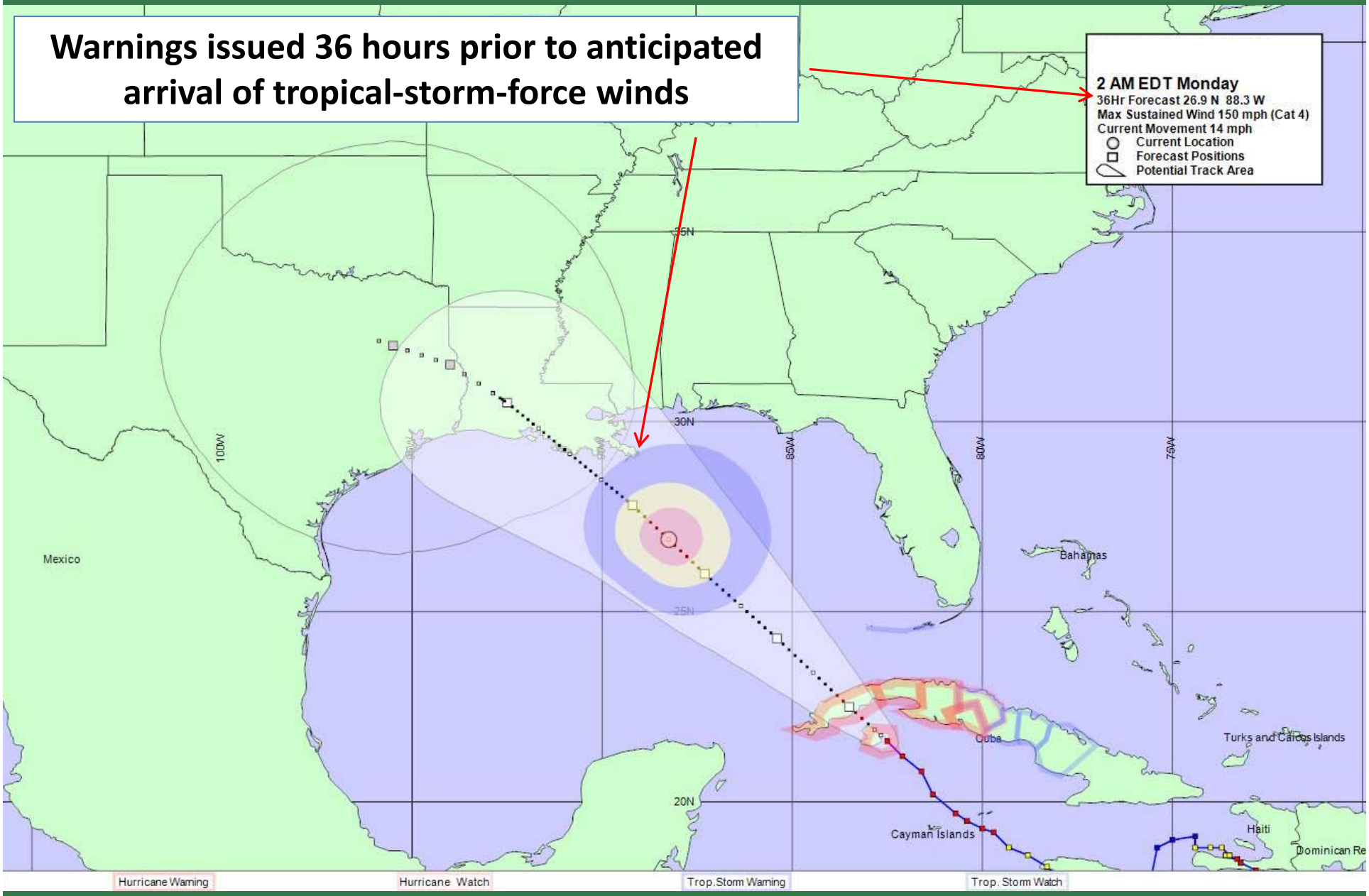


Issuing Warnings

What area would you issue a hurricane warning for?

Issuing Warnings

What area would you issue a hurricane warning for?

Must account for track and size (wind radii) uncertainties when issuing watches or warnings

Issuing Warnings – Storm Approaching at an Acute Angle

What area would you issue a hurricane warning for?

Issuing Warnings – Storm Approaching at an Acute Angle

What area would you issue a hurricane warning for?

International Coordination

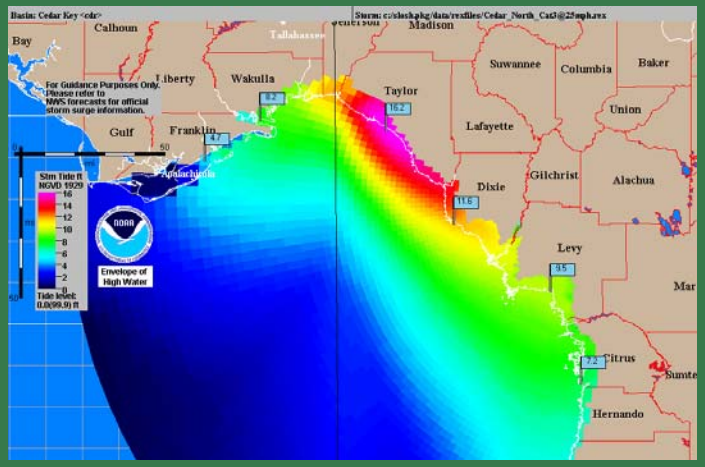
World MET. ORGANIZATION - Regional Association IV Coordination

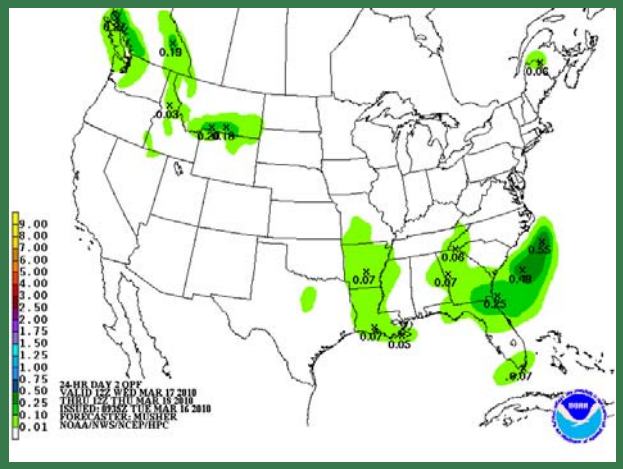
RSMC= Regional Specialized Meteorological Center

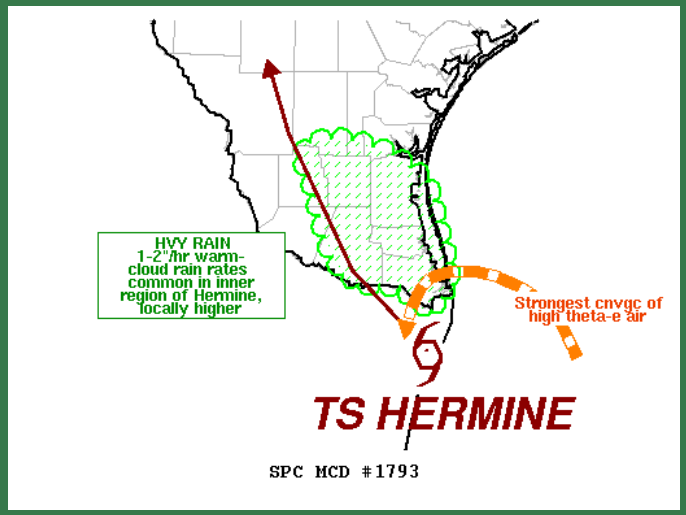
RA-IV countries include Caribbean area, Central America, Mexico, Canada, and Bermuda.

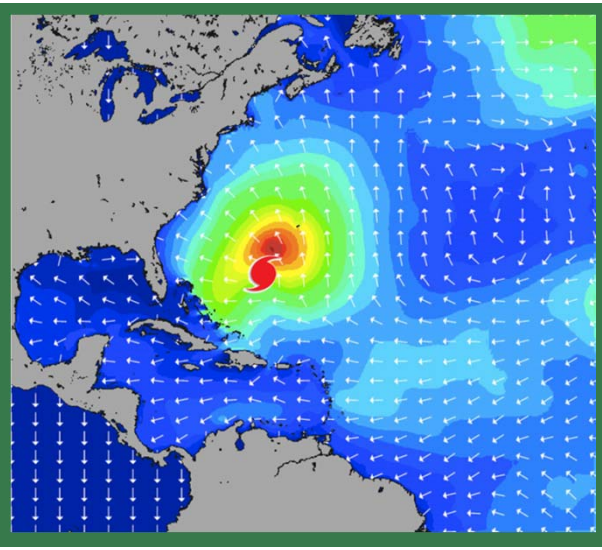
2:00 NWS / DOD Coordination Call

- Coordinate and determine watches/ warnings
- Coordinate storm surge, rainfall, tornado, rip current hazards



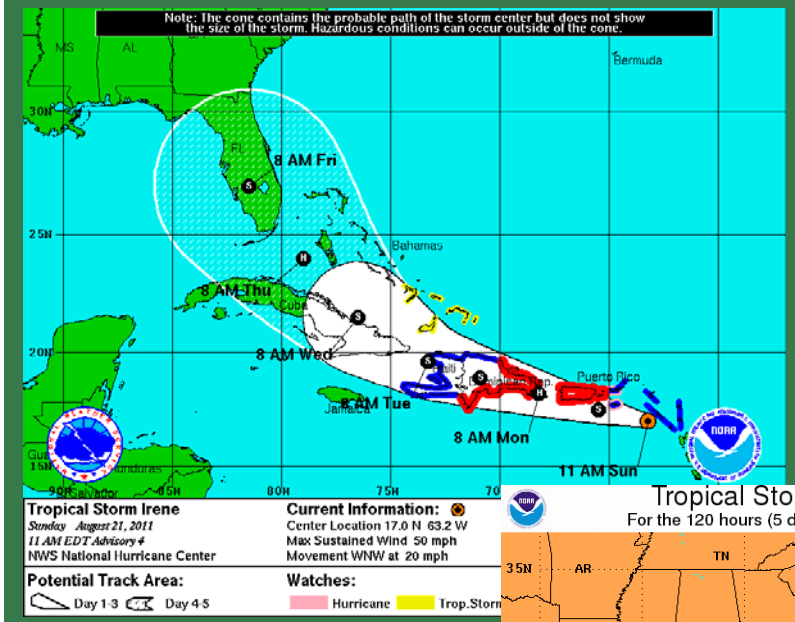


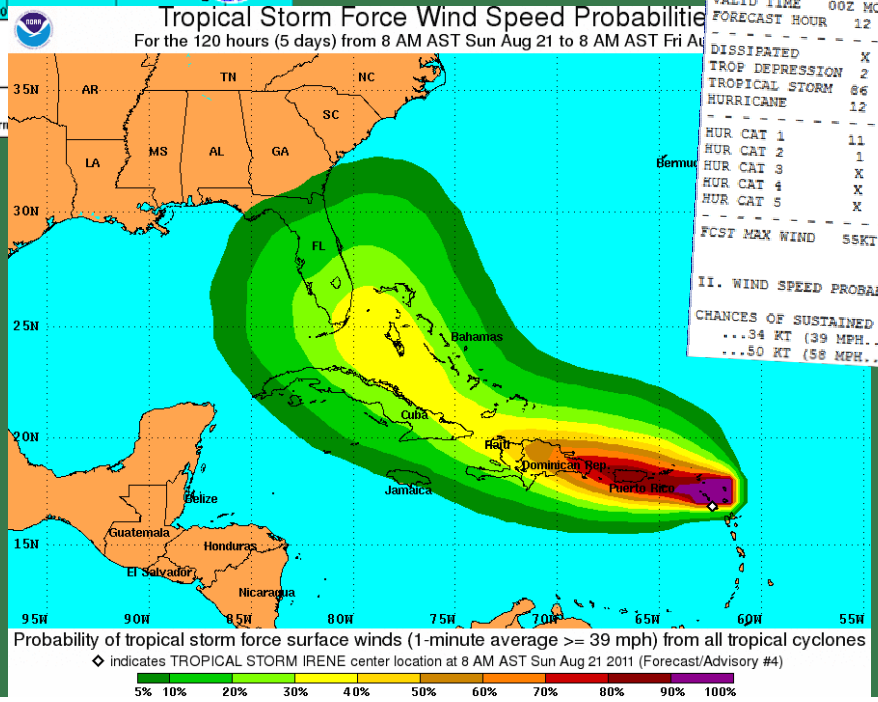




3:00 Advisory deadline

Prepare and issue forecast products



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ZCZC MIAPWSAT4 ALL
TTAA00 KNHC DDHHMM

TROPICAL STORM IRENE WIND SPEED PROBABILITIES NUMBER   4
NWS NATIONAL HURRICANE CENTER MIAMI FL       AL092011
1500 UTC SUN AUG 21 2011

AT 1500Z THE CENTER OF TROPICAL STORM IRENE WAS LOCATED NEAR
LATITUDE 17.0 NORTH...LONGITUDE 63.2 WEST WITH MAXIMUM SUSTAINED
WINDS NEAR 45 KTS...50 MPH...85 KM/H.

Z INDICATES COORDINATED UNIVERSAL TIME (GREENWICH)
   ATLANTIC STANDARD TIME (AST)...SUBTRACT 4 HOURS FROM Z TIME
   EASTERN  DAYLIGHT TIME (EDT)...SUBTRACT 4 HOURS FROM Z TIME
   CENTRAL  DAYLIGHT TIME (CDT)...SUBTRACT 5 HOURS FROM Z TIME


I.  MAXIMUM WIND SPEED (INTENSITY) PROBABILITY TABLE

CHANCES THAT THE MAXIMUM SUSTAINED (1-MINUTE AVERAGE) WIND SPEED OF
THE TROPICAL CYCLONE WILL BE WITHIN ANY OF THE FOLLOWING CATEGORIES
AT EACH OFFICIAL FORECAST TIME DURING THE NEXT 5 DAYS.
PROBABILITIES ARE GIVEN IN PERCENT.  X INDICATES PROBABILITIES LESS
THAN 1 PERCENT.


      - - - MAXIMUM WIND SPEED (INTENSITY) PROBABILITIES - - -

VALID TIME   00Z MON 12Z MON 00Z TUE 12Z TUE 12Z WED 12Z THU 12Z FRI
FORECAST HOUR   12     24     36     48     72     96     120
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
DISSIPATED       X      1      2     11     14     14     18
TROP DEPRESSION  2      5     12     31     25     10     10
TROPICAL STORM  86     58     65     50     50     45     46
HURRICANE       12     37     21      8     11     30     26
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
HUR CAT 1       11     31     17      7     10     23     21
HUR CAT 2        1      4      3      1      1      5      4
HUR CAT 3        X      1      1      X      X      2      1
HUR CAT 4        X      X      X      X      X      X      X
HUR CAT 5        X      X      X      X      X      X      X
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
FCST MAX WIND  55KT   65KT   50KT   45KT   50KT   65KT   50KT


II. WIND SPEED PROBABILITY TABLE FOR SPECIFIC LOCATIONS

CHANCES OF SUSTAINED (1-MINUTE AVERAGE) WIND SPEEDS OF AT LEAST
   ...34 KT (39 MPH... 63 KPH)...
   ...50 KT (58 MPH... 93 KPH)...
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EM Conference Calls and Media Interviews

Hurricane Liaison Team

Media Interviews