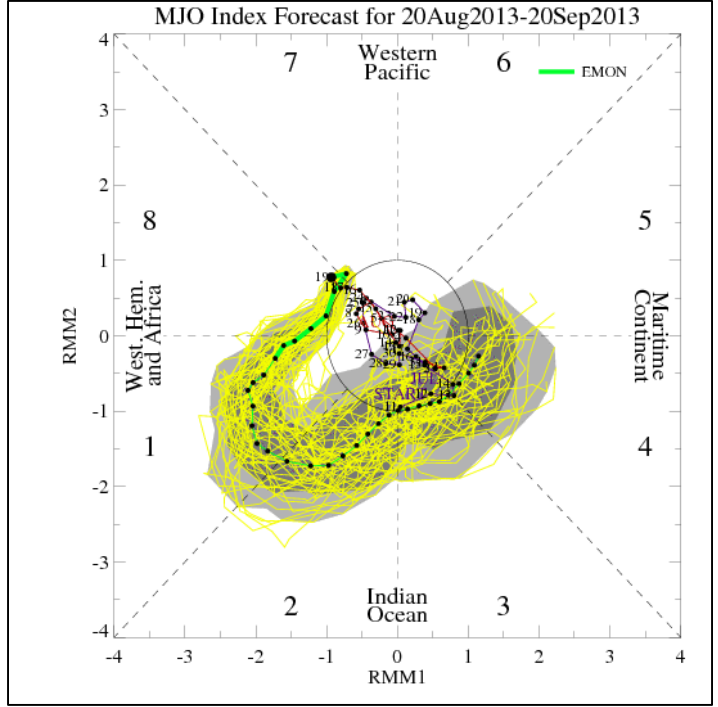
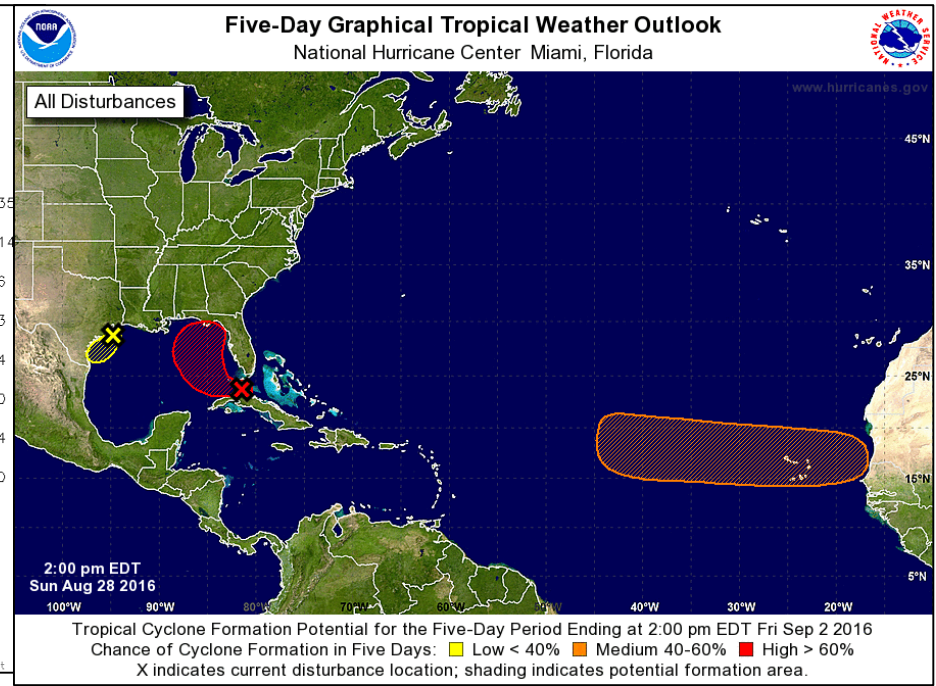
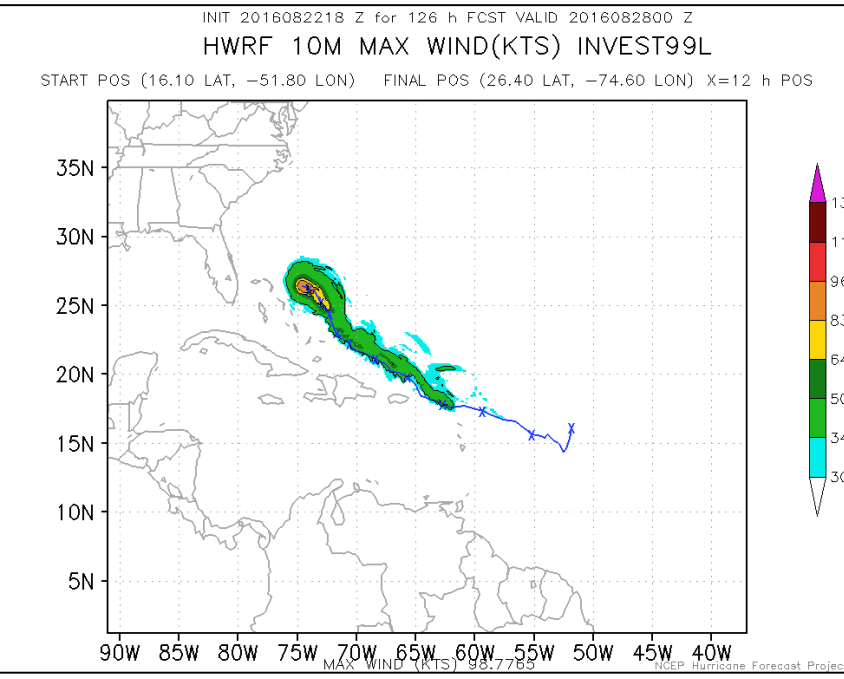




# Tropical Cyclone Genesis Forecasting and Pre-Genesis Forecasts

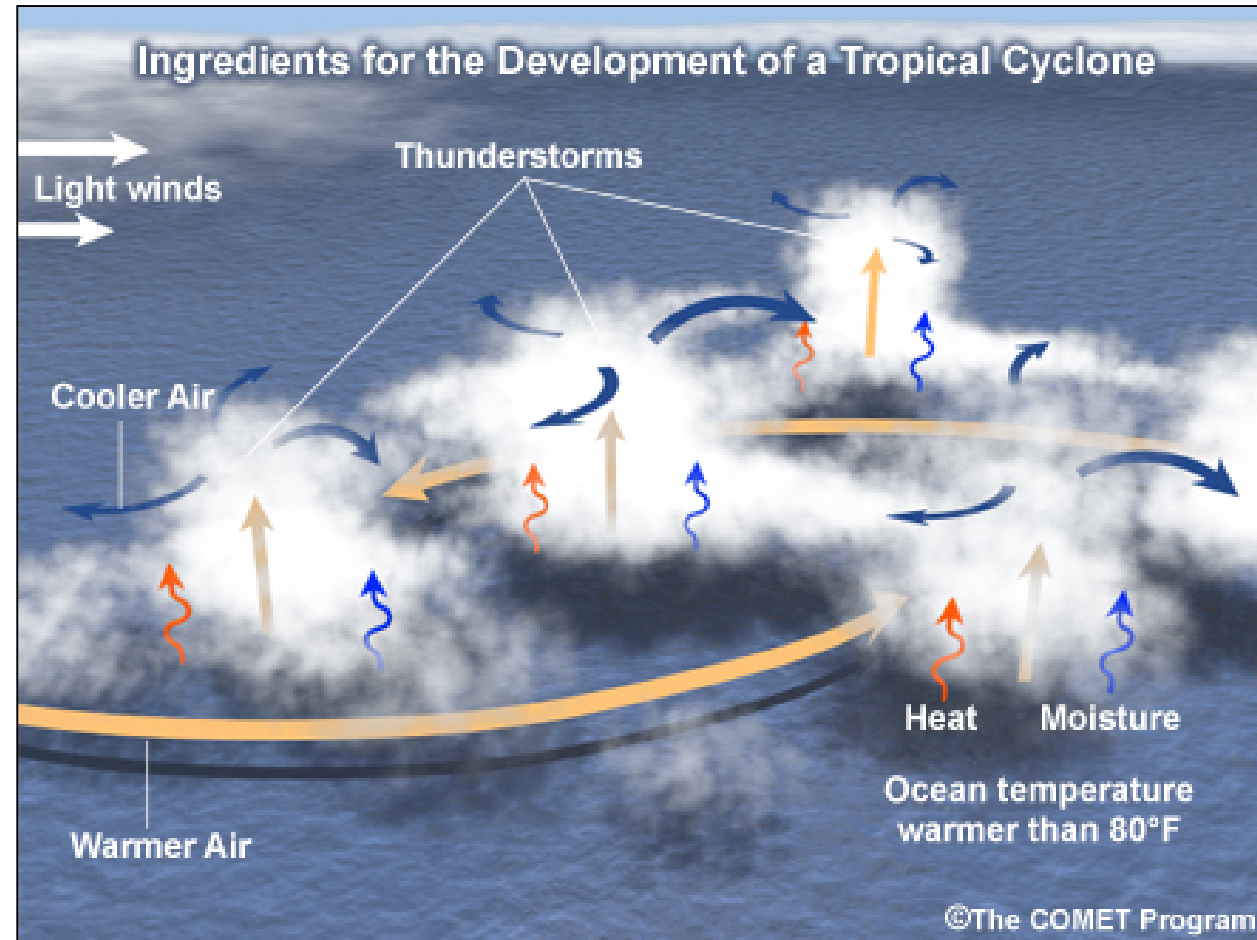


Meteorology Workshop 3 – Potential Tropical Cyclones  
 Michael Brennan  
 National Hurricane Center  
 20 April 2017

# Necessary Conditions for TC Formation

*Necessary but not sufficient conditions!*

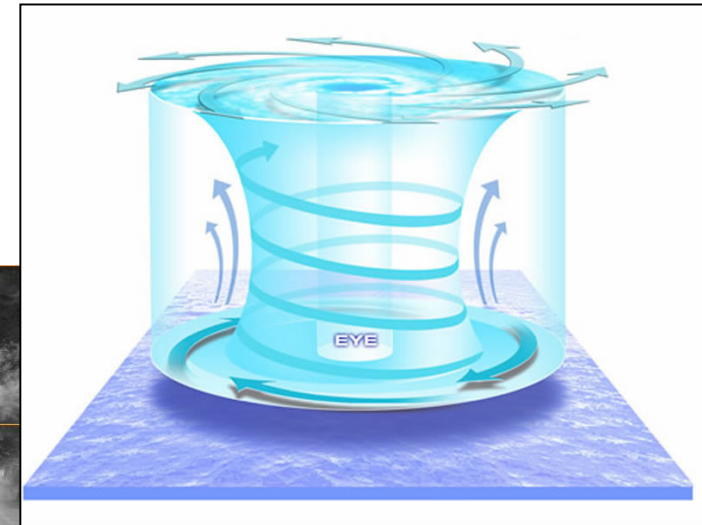
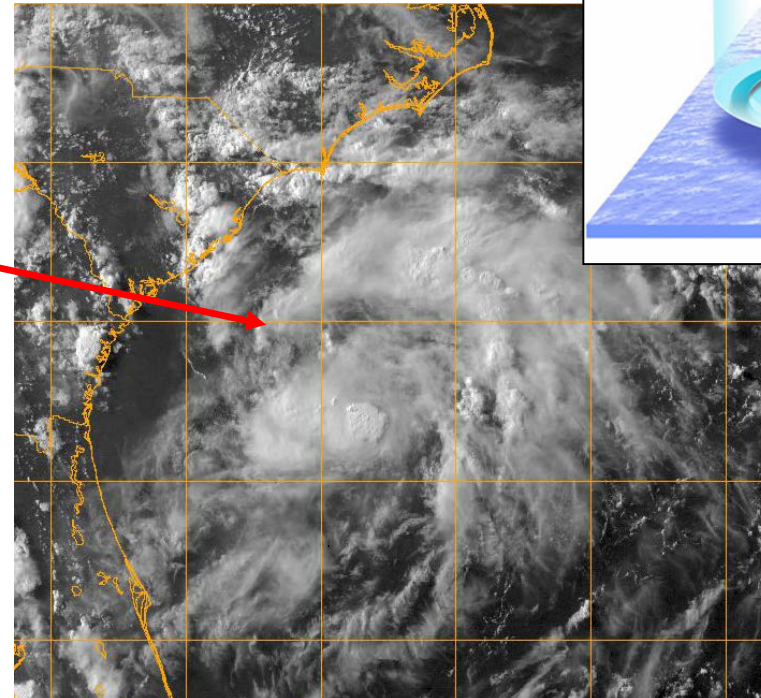
- A pre-existing disturbance containing abundant deep convection
- Latitude poleward of  $\sim 5^\circ$
- Adequate ocean thermal energy
  - SST  $> 26^\circ\text{C}$  extending to a depth of 60 m
- A sufficiently unstable atmosphere and deep layer of moist air
- Small vertical shear of the horizontal wind



# Necessary Conditions for TC Formation

*Necessary but not sufficient conditions!*

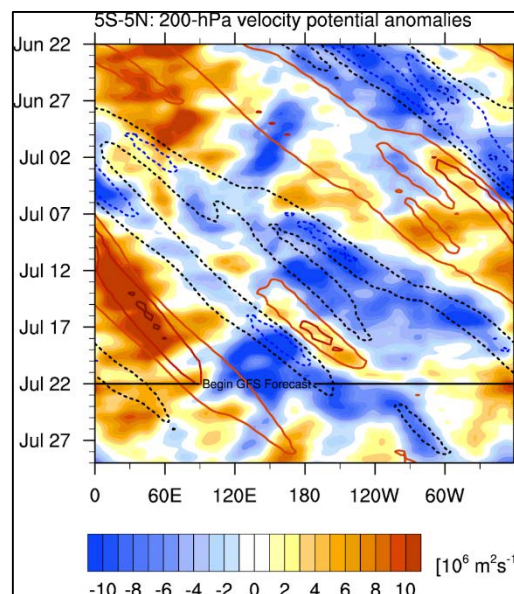
- Upper-tropospheric anticyclonic outflow over the area
- Enhanced lower tropospheric relative vorticity
- Appearance of curved banding features in the deep convection
- Falling surface pressure: 24-hour pressure changes (falls) of usually 3 mb or more



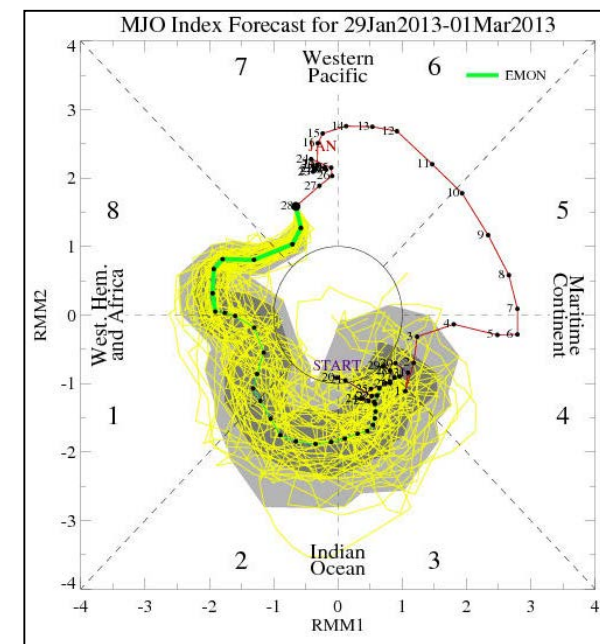


# TC Genesis Forecasting – Large Scale Factors

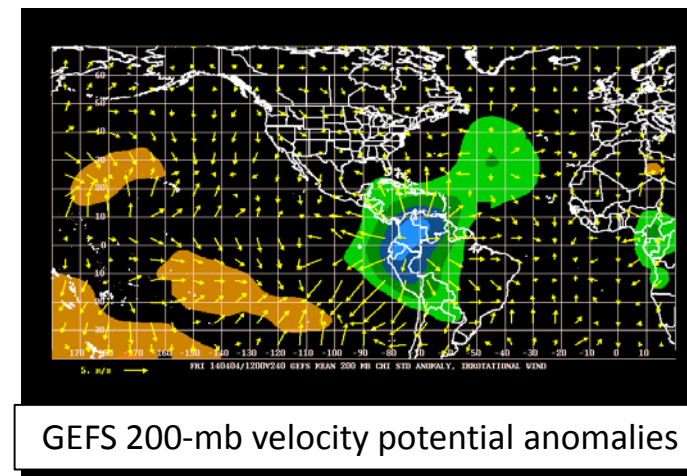
- Diagnostic tools involving the Madden-Julian Oscillation (MJO) and other intraseasonal oscillations such as Kelvin Waves are increasingly examined, but are still used qualitatively
- Adjustments to genesis probabilities based on intraseasonal signals are usually small and subjectively determined
- Global models handle the MJO much more accurately than individual Kelvin Waves, and thus the forecaster can add value to the deterministic model output



Hovmöller Diagram showing 200-mb velocity potential anomaly filtered for Kelvin Wave tracking

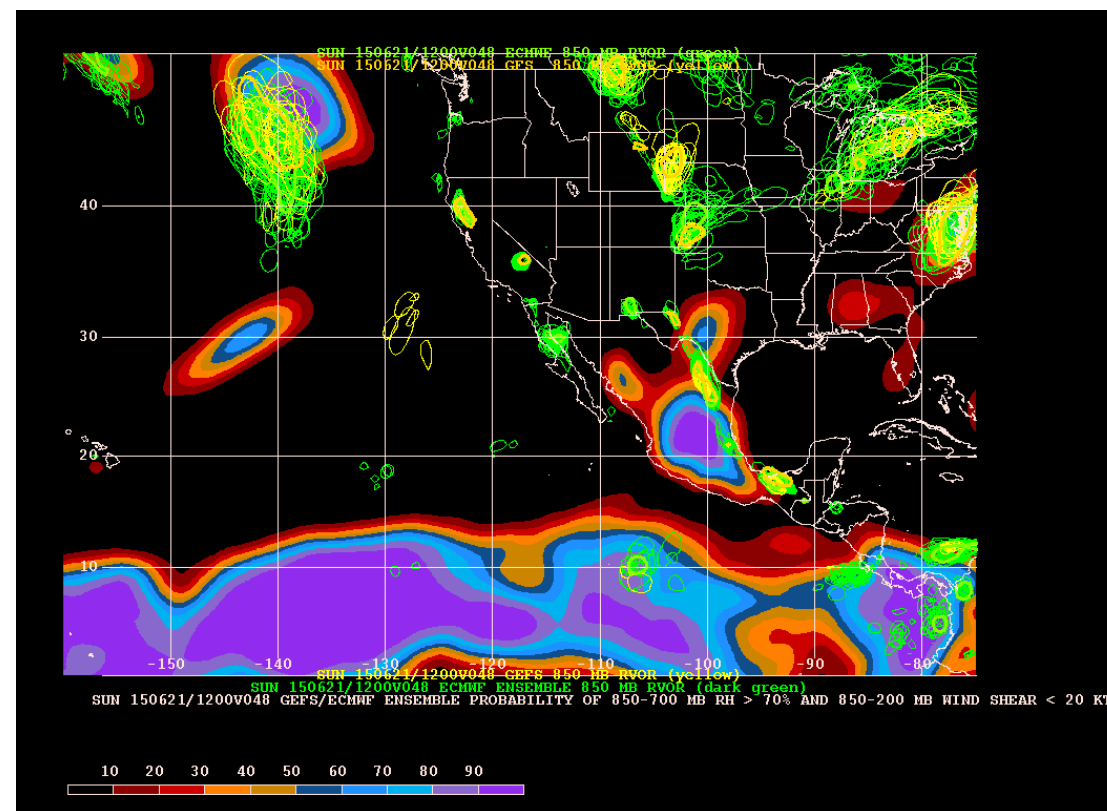


MJO Wheeler Diagram Forecast



# TC Genesis Forecasting – Global Models

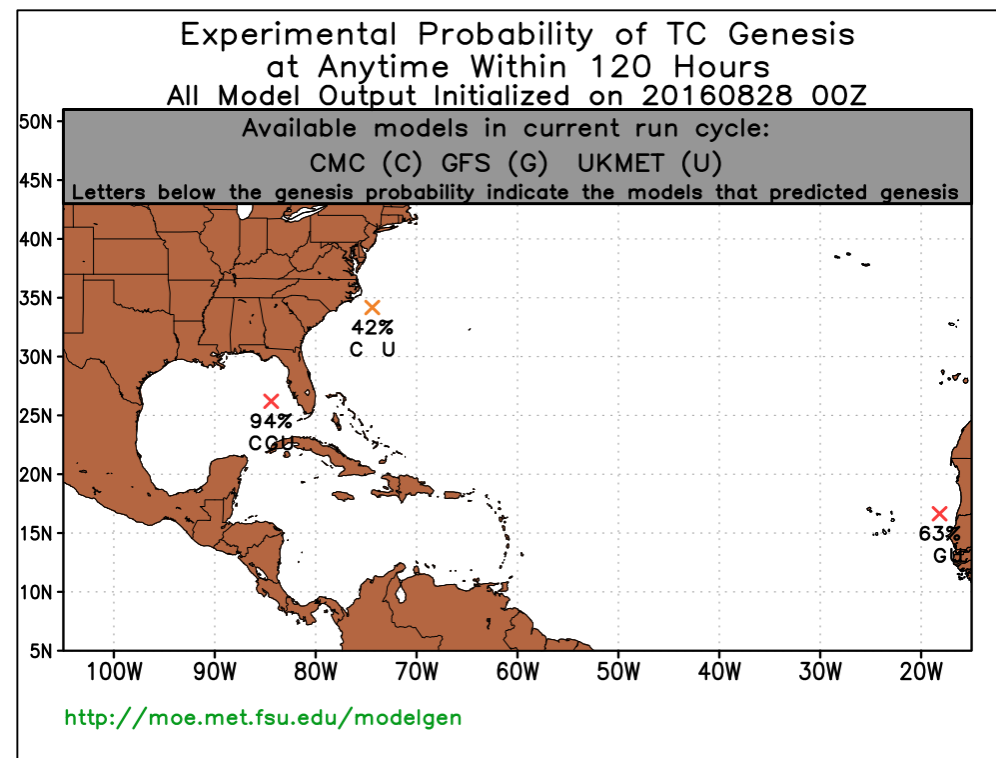
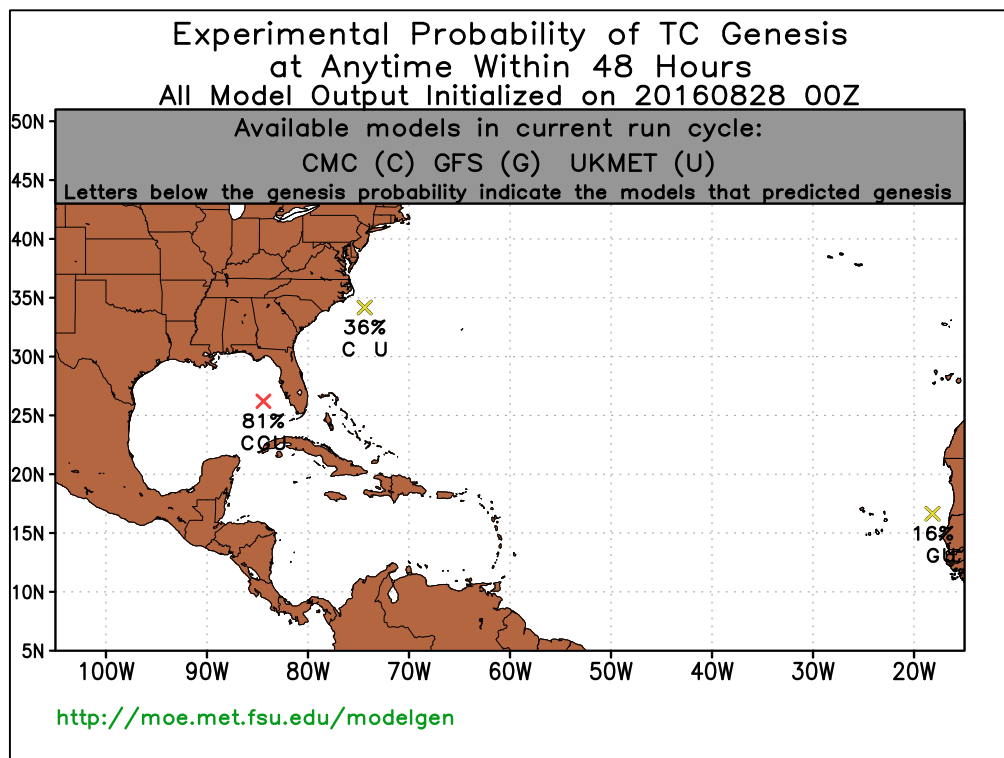
- Global models, especially the ECMWF, GFS, and UKMET along with their ensembles are the primary tool for predicting TC genesis
  - Used to assess the development of the disturbance itself and to examine environmental factors that contribute to genesis
- Forecaster looks for consistency between models and run-to-run consistency
- Recent upgrades to the ECMWF have probably improved that model's performance
- 2016 changes to the GFS degraded its ability to forecast genesis, especially in the eastern North Pacific (hoping for some improvement in 2017)
- UKMET model has a high detection rate for genesis but also has an abundance of false alarms
- The Canadian global model typically shows the highest number of false alarms



Combined ECMWF/GFS ensemble product showing the probability of 850-200-mb shear < 20 kt and 850-700 mb RH > 70% with 850-mb relative vorticity contours

# TC Genesis Forecasting – Global Models

- Joint Hurricane Testbed project at Florida State University produces bias-corrected probabilistic TC genesis forecasts from global models
  - FSU version includes the GFS, UKMET, and CMC
- Provides disturbance-based probabilities of TC genesis in 48 h and 5 day periods to correspond to NHC’s Tropical Weather Outlook



48-h and 5-day genesis probabilities from 00 UTC model cycle on 28 August 2016



# Tropical Weather Outlook



- General assessment of activity in the tropics
- Assesses tropical cyclone formation potential during the next 5 days
- Probabilities of genesis during the first 48 hours and the entire 5-day period are provided
- Issued at 0000 UTC, 0600 UTC, 1200 UTC, 1800 UTC

ABNT20 KNHC 061154  
TWOAT

TROPICAL WEATHER OUTLOOK  
NWS NATIONAL HURRICANE CENTER MIAMI FL  
800 AM EDT SAT AUG 6 2016

For the North Atlantic...Caribbean Sea and the Gulf of Mexico:

The National Hurricane Center is issuing advisories on Tropical Depression Earl, located well inland over Mexico west of Veracruz.

An area of cloudiness and thunderstorms associated with a trough of low pressure is located over the northeastern Gulf of Mexico. Some gradual development is possible before the system moves inland over the southeastern United States in a couple of days. Regardless of development, heavy rainfall over northern Florida is anticipated.

\* Formation chance through 48 hours...low...20 percent

\* Formation chance through 5 days...low...30 percent

A tropical wave is producing disorganized cloudiness and showers just north of Puerto Rico and the adjacent Atlantic. An area of low pressure could form in the middle of next week between Florida and Bermuda while the activity moves west-northwestward and then northward over the Atlantic.

\* Formation chance through 48 hours...low...near 0 percent

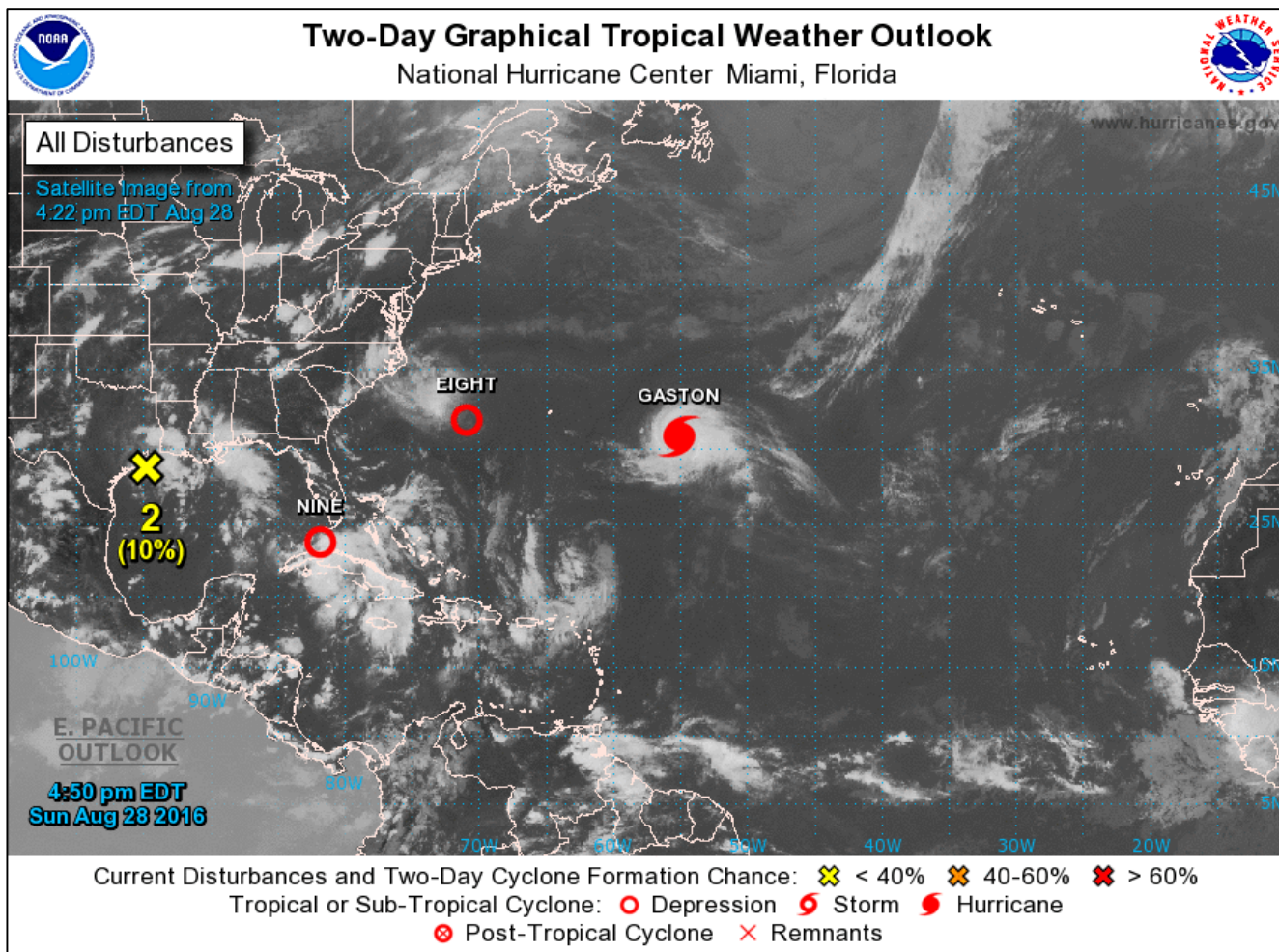
\* Formation chance through 5 days...low...20 percent

\$\$  
Forecaster Avila



# Graphical Tropical Weather Outlook

## 2-Day Formation Chance

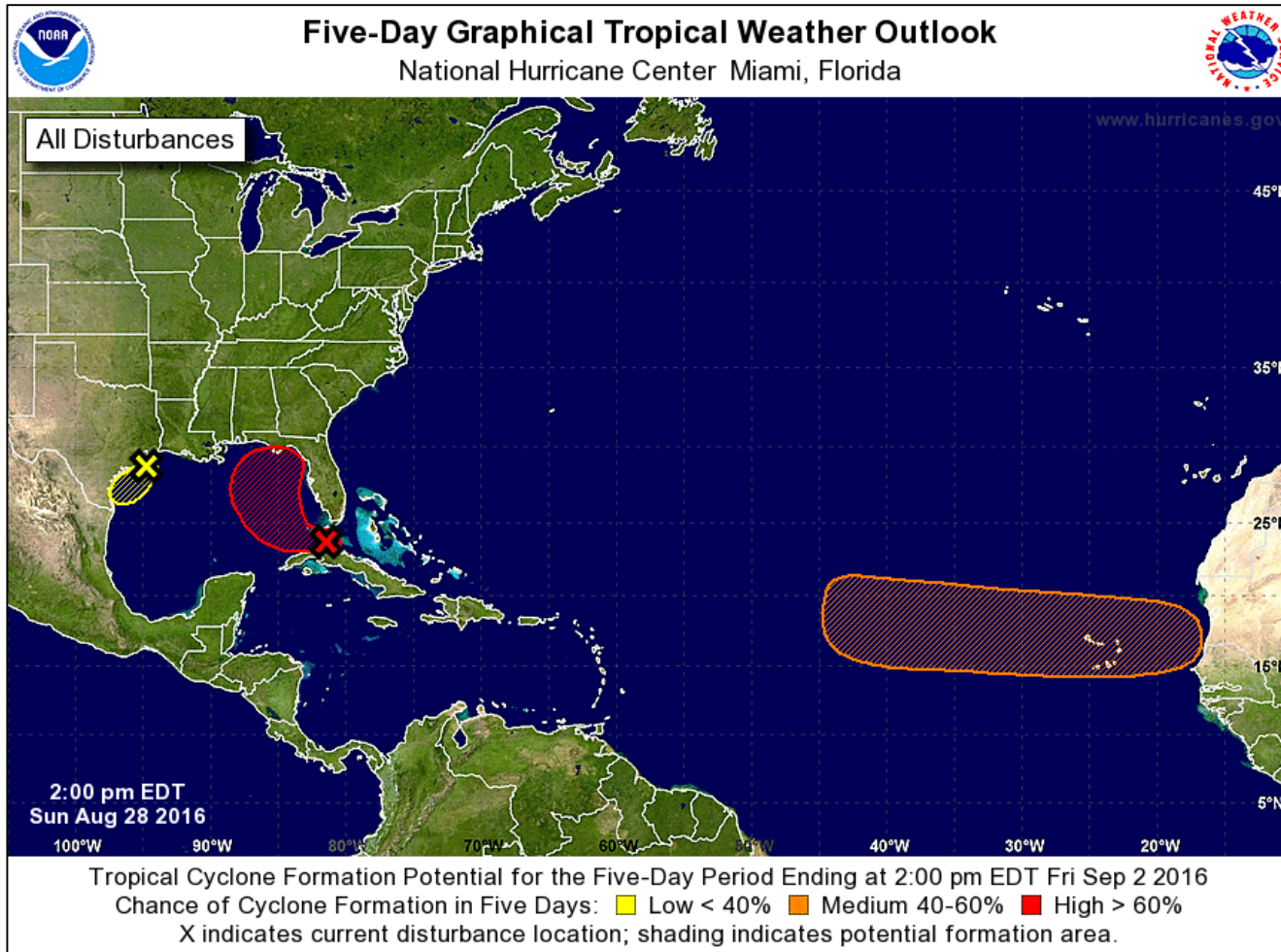


- Identifies current location of disturbances discussed in the TWO
- Shows formation chance during the next 48 hours
  - Categorical (Low, Medium, and High)
  - Probabilities to nearest 10%
- Shows current location of active systems that NHC is writing advisories on



# Graphical Tropical Weather Outlook

## 5-Day Formation Chance



- Shows formation potential during the next 5 days
- Initial location of disturbance (X) indicated, if existing at issuance time
- Shading represents potential formation area (not shown for Potential Tropical Cyclones)
- Active tropical cyclones will be shown starting in 2017



# Special Tropical Weather Outlook



Issued for Significant or Unexpected Changes

ABNT20 KNHC 241532  
TWOAT

SPECIAL TROPICAL WEATHER OUTLOOK  
NWS NATIONAL HURRICANE CENTER MIAMI FL  
1135 AM EDT WED AUG 24 2016

For the North Atlantic...Caribbean Sea and the Gulf of Mexico:

Special Tropical Weather Outlook issued to update discussion on tropical wave in the Caribbean.

The National Hurricane Center is issuing advisories on Tropical Storm Gaston, located about 1000 miles west of the Cabo Verde Islands.

Updated: An Air Force Reconnaissance aircraft currently investigating the broad low pressure area and tropical wave near the northern Leeward Islands has found winds to tropical storm force in a few squalls near the northernmost Leeward Islands. Squalls to tropical storm force can be expected over the extreme northern Leeward Islands and portions of the northern U.S. and British Virgin Islands this afternoon. The reconnaissance aircraft mission is ongoing to determine whether or not a tropical cyclone has formed.

Although environmental conditions are currently only marginally conducive for additional development, this system could become a tropical depression or tropical storm at any time during the next few days while it moves west-northwestward at about 15 mph across the northern Leeward Islands, near or over Puerto Rico, Hispaniola, and the Bahamas. Strong winds, heavy rains, and possible flash floods and mudslides are expected to occur over portions of the Leeward Islands, Puerto Rico, Hispaniola, and the southeastern and central Bahamas. Please consult products issued by your local meteorological offices for further details. Interests in the northwestern Bahamas and Florida should also monitor the progress of this system.

\* Formation chance through 48 hours...medium...60 percent  
\* Formation chance through 5 days...high...80 percent

\$\$  
Forecaster Brown

- Reason(s) for special outlook issuance provided
- New information provided for “Updated” disturbance



# Special Tropical Weather Outlook



## Issued for Significant or Unexpected Changes or

ABNT20 KNHC 281413  
TWOAT

SPECIAL TROPICAL WEATHER OUTLOOK  
NWS NATIONAL HURRICANE CENTER MIAMI FL  
1015 AM EDT SUN AUG 28 2016

For the North Atlantic...Caribbean Sea and the Gulf of Mexico:

Special Outlook issued to update discussion of area of low pressure west of Bermuda.

The National Hurricane Center is issuing advisories on Hurricane Gaston, located about 600 miles east of Bermuda.

A weak area of low pressure located near the north coast of central Cuba continues to produce a large area of disorganized cloudiness and thunderstorms. Upper-level winds are not conducive for significant development today while this system moves westward through the Straits of Florida. The low is expected to move into the southeastern Gulf of Mexico on Monday, where environmental conditions could become somewhat more conducive for development. Regardless of development, heavy rainfall and gusty winds are likely over portions of the central and northwestern Bahamas, and Cuba through tonight. Gusty winds and locally heavy rainfall will spread into parts of southern Florida and the Florida Keys later today. Interests elsewhere in Florida and the eastern Gulf of Mexico should continue to monitor the progress of this disturbance. A NOAA Hurricane Hunter aircraft is scheduled to investigate this system this afternoon, if necessary.

\* Formation chance through 48 hours...medium...40 percent  
\* Formation chance through 5 days...medium...60 percent

Updated: Satellite images indicate that the area of low pressure west-southwest of Bermuda has become a tropical depression, and advisories on Tropical Depression Eight will be initiated at 11 AM EDT.

\* Formation chance through 48 hours...high...100 percent  
\* Formation chance through 5 days...high...100 percent

- Reason(s) for special outlook issuance provided
- New information provided for “Updated” disturbance





# NHC TC Genesis Forecast Verification



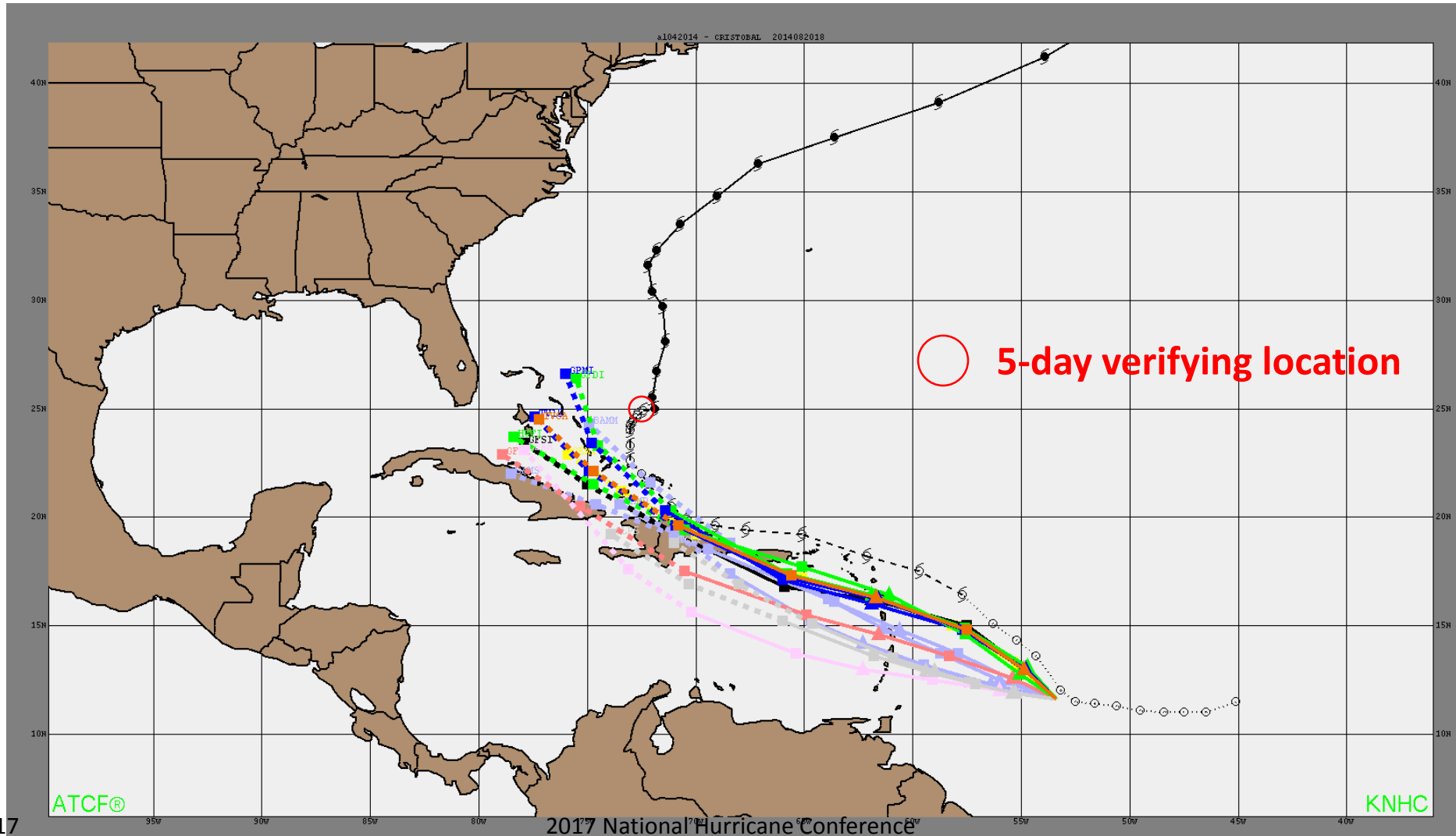


# Track Guidance for Invests

- “Invests” are suspect areas that NHC is interested in looking at more closely for a variety of reasons
- Model guidance for invests should be treated with *extreme caution*
  - Track and intensity guidance for invests can be unreliable and show large swings from one cycle to the next for several reasons:
    - The models may not have a good representation of the invest in the initial analysis (can be too weak, too strong, or in the wrong place)
    - The initial position and motion of invests can be highly uncertain
    - Invests can be relocated many 10s of miles from one cycle to the next as new data become available
- Always refer to Potential Tropical Cyclone advisories and the TWO for information about possible tropical cyclones

# Guidance for Invests

## *Pre-Cristobal – 18Z 20 Aug. 2014*

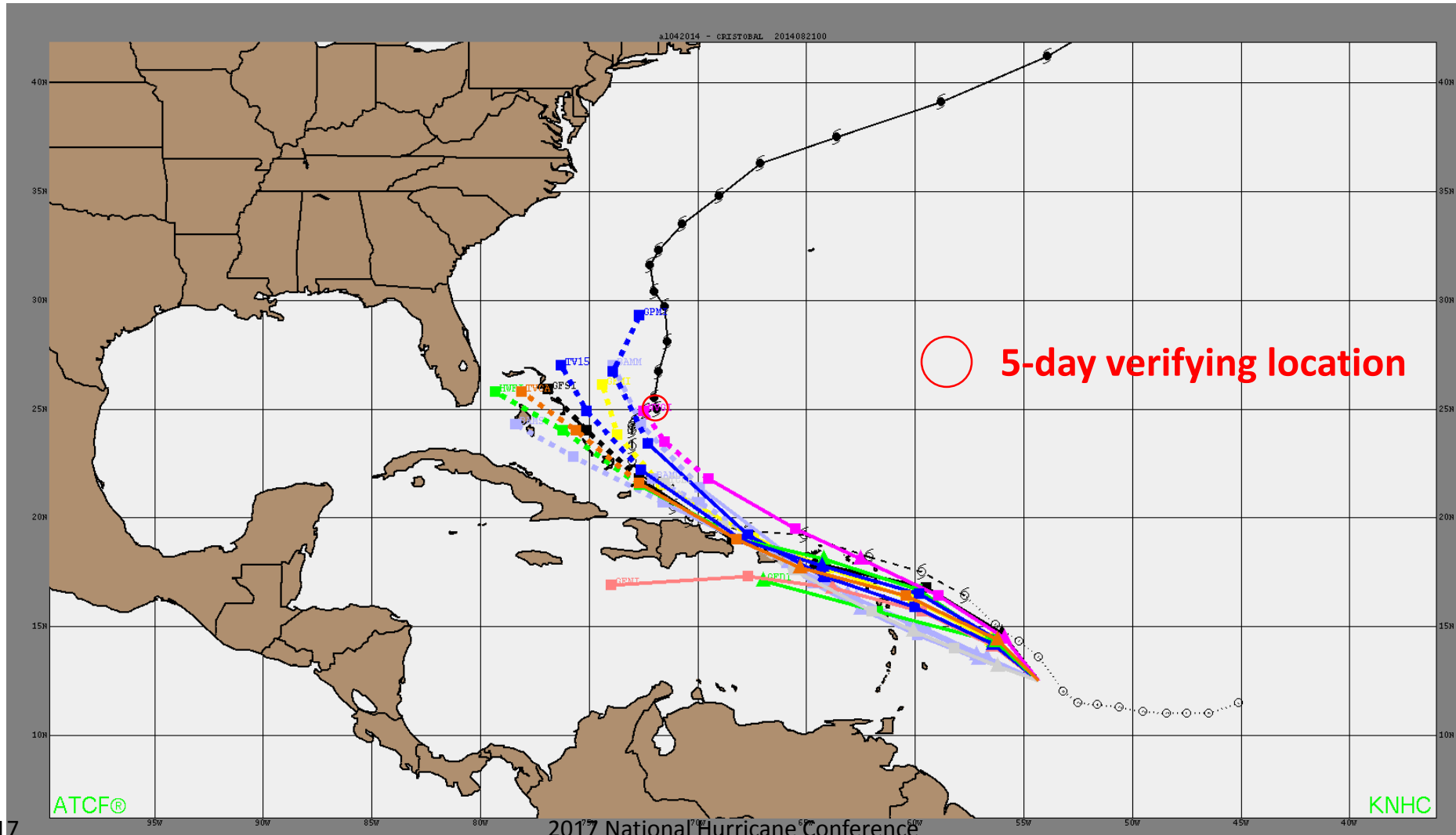






# Guidance for Invests

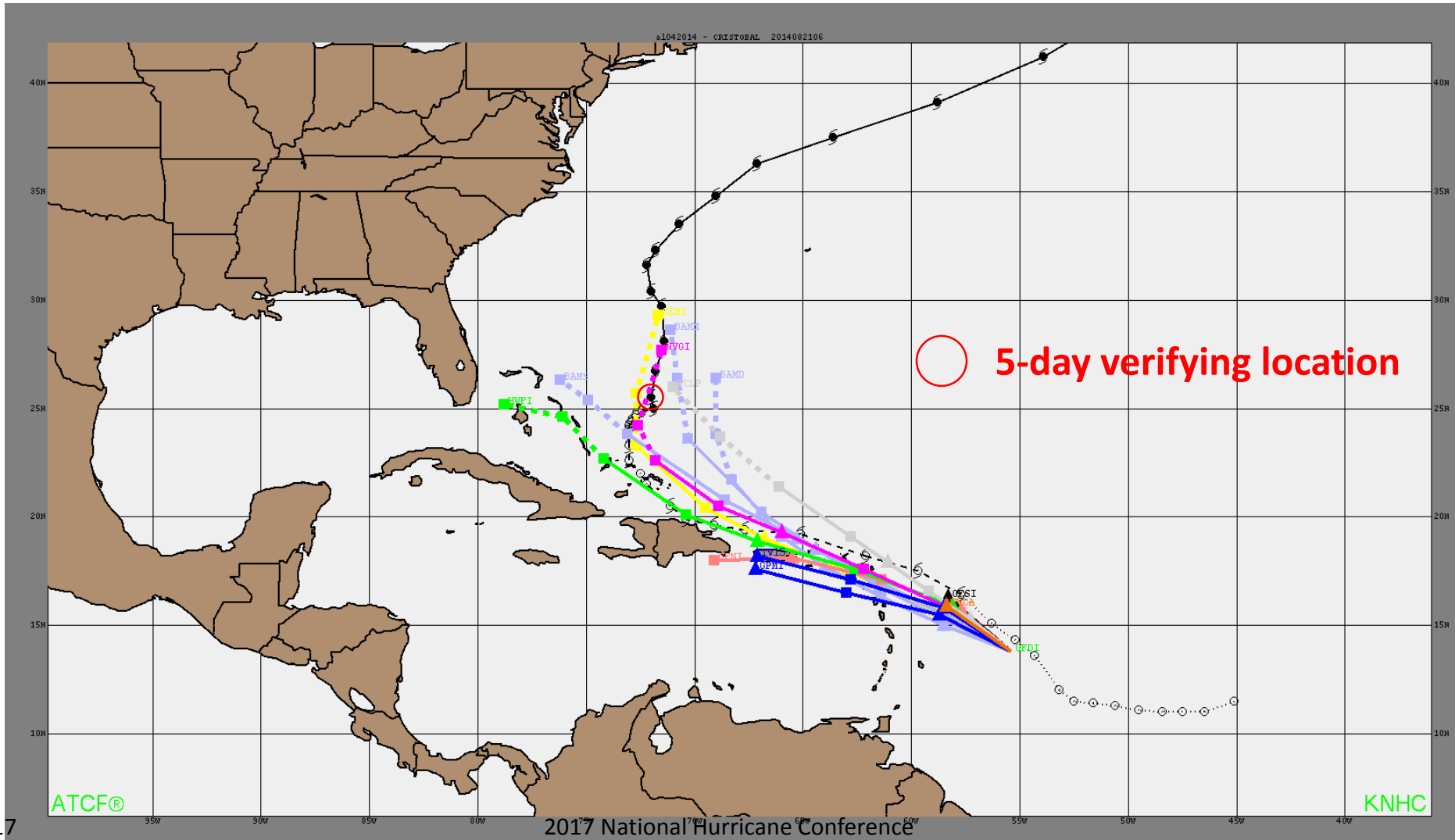
## *Pre-Cristobal – 00Z 21 Aug. 2014*





# Guidance for Invests

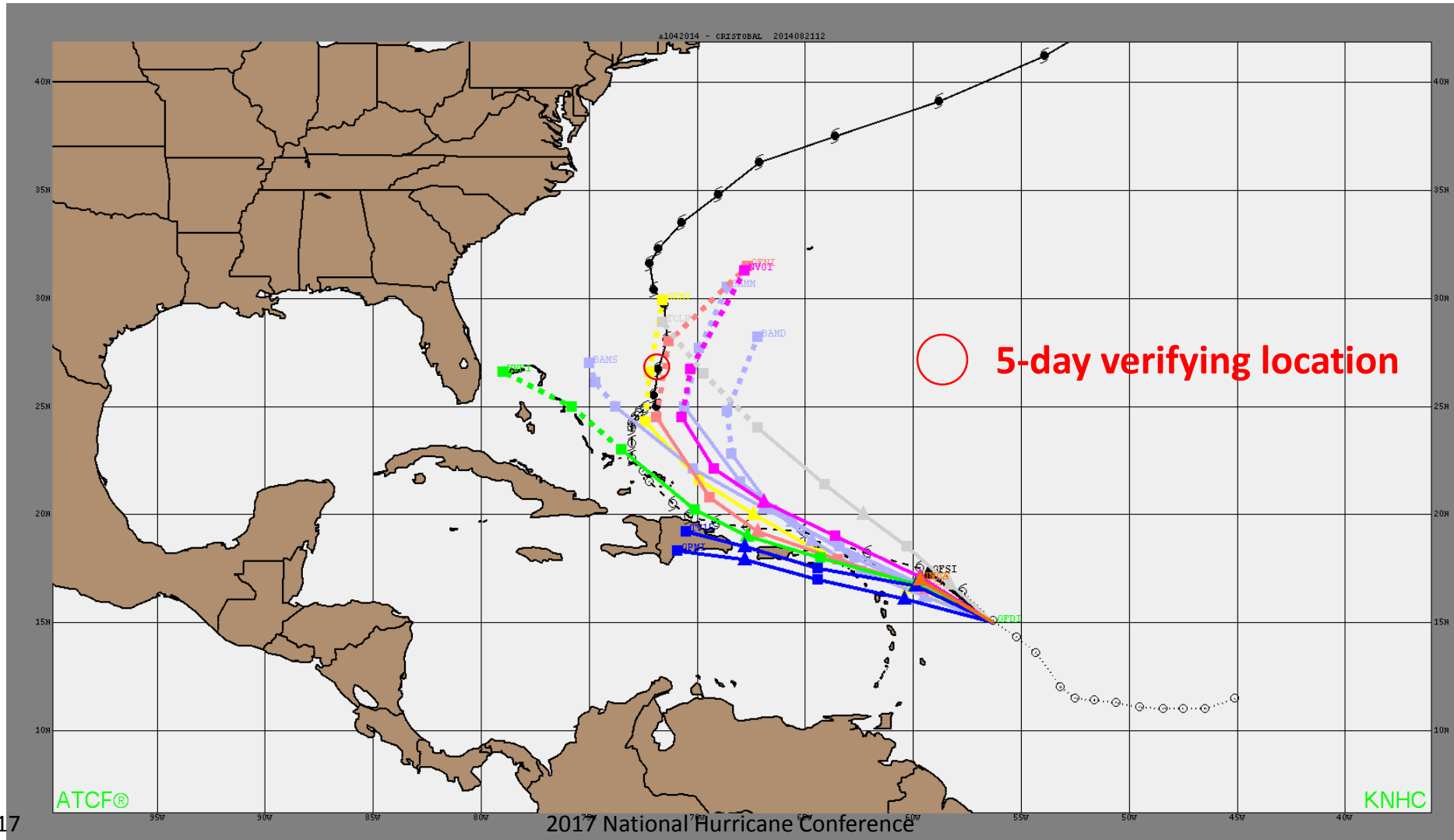
## Pre-Cristobal – 06Z 21 Aug. 2014





# Guidance for Invests

## *Pre-Cristobal – 12Z 21 Aug. 2014*

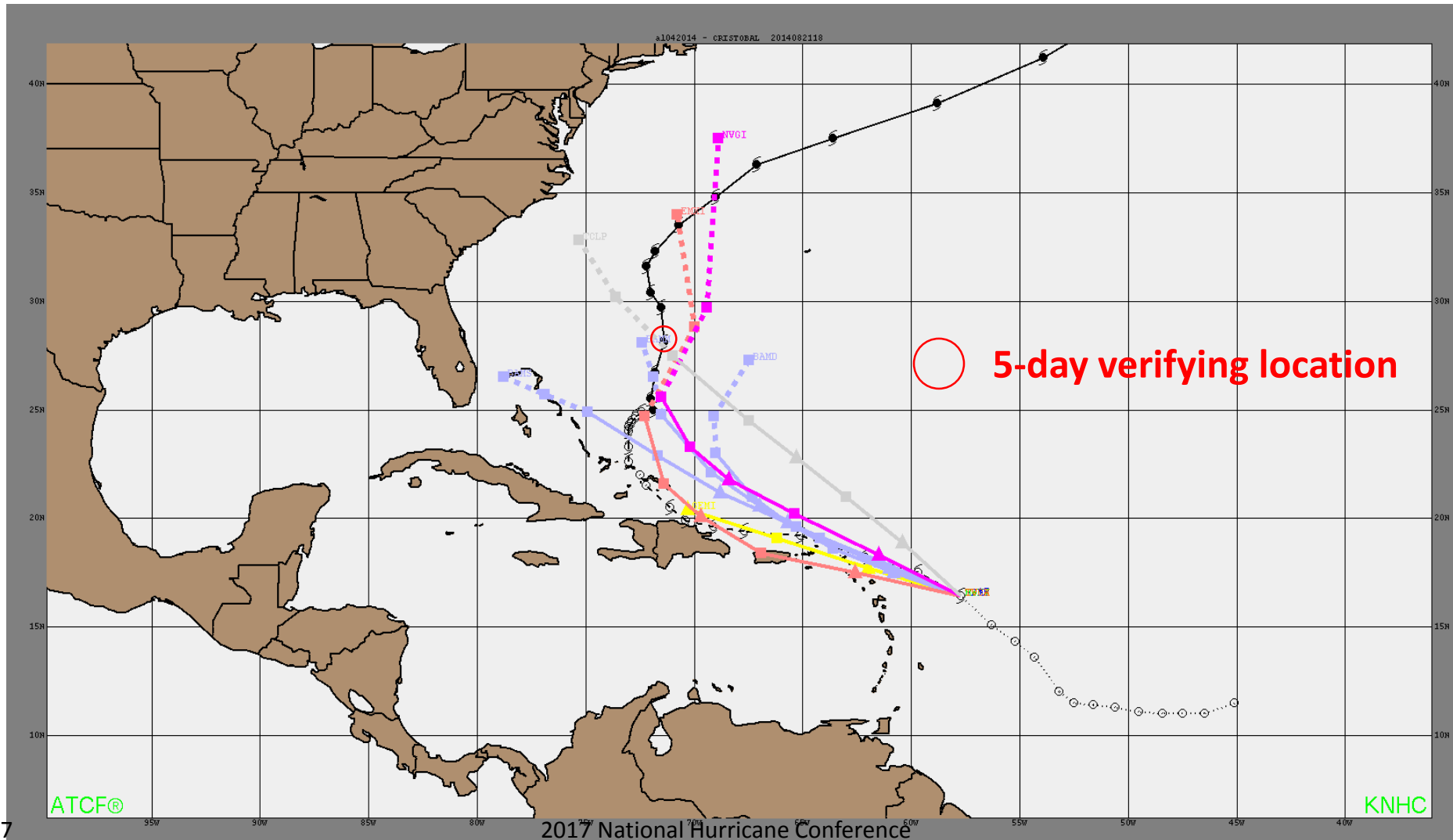






# Guidance for Invests

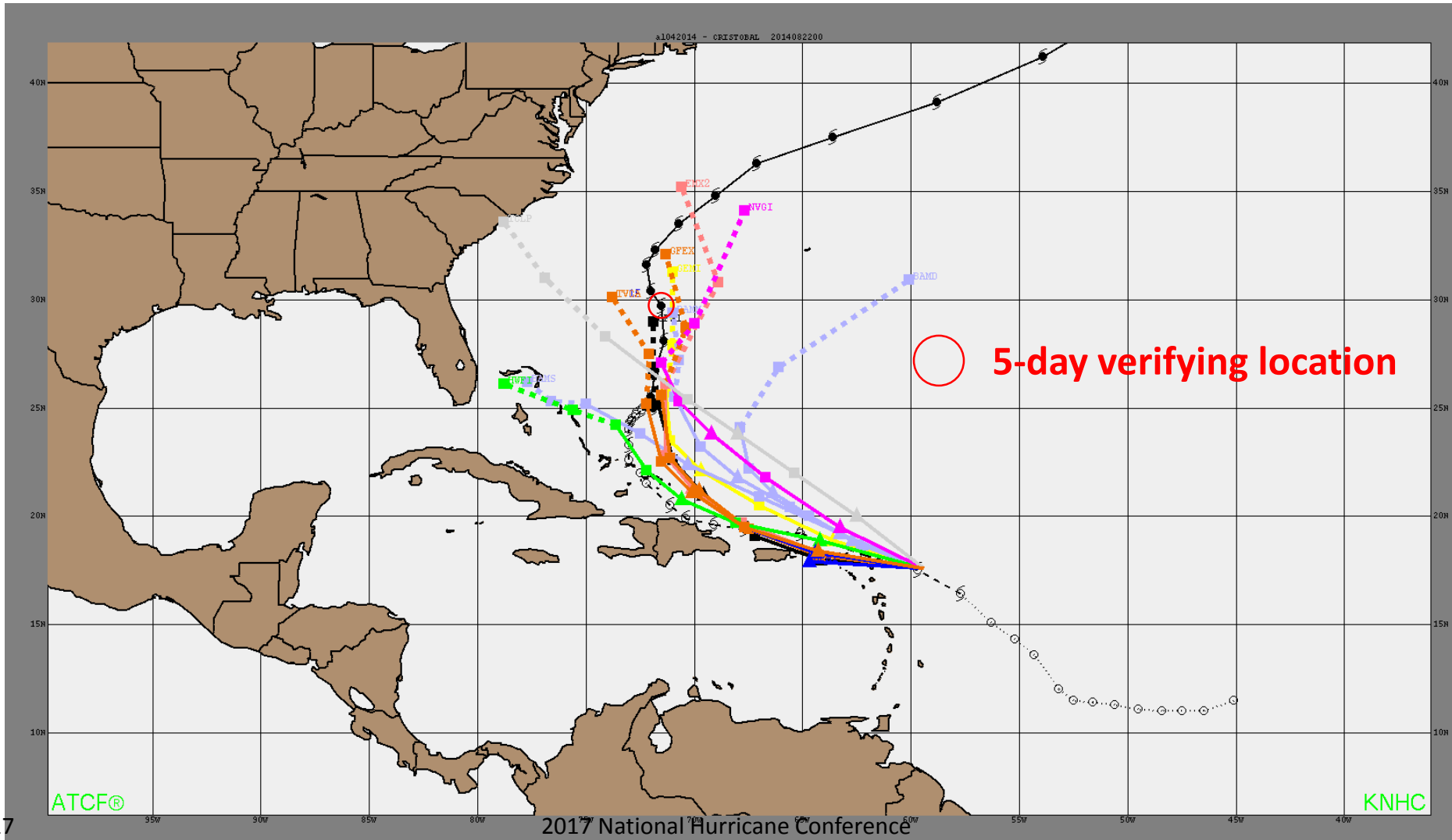
## *Pre-Cristobal – 18Z 21 Aug. 2014*





# Guidance for Invests

## *Pre-Cristobal – 00Z 22 Aug. 2014*

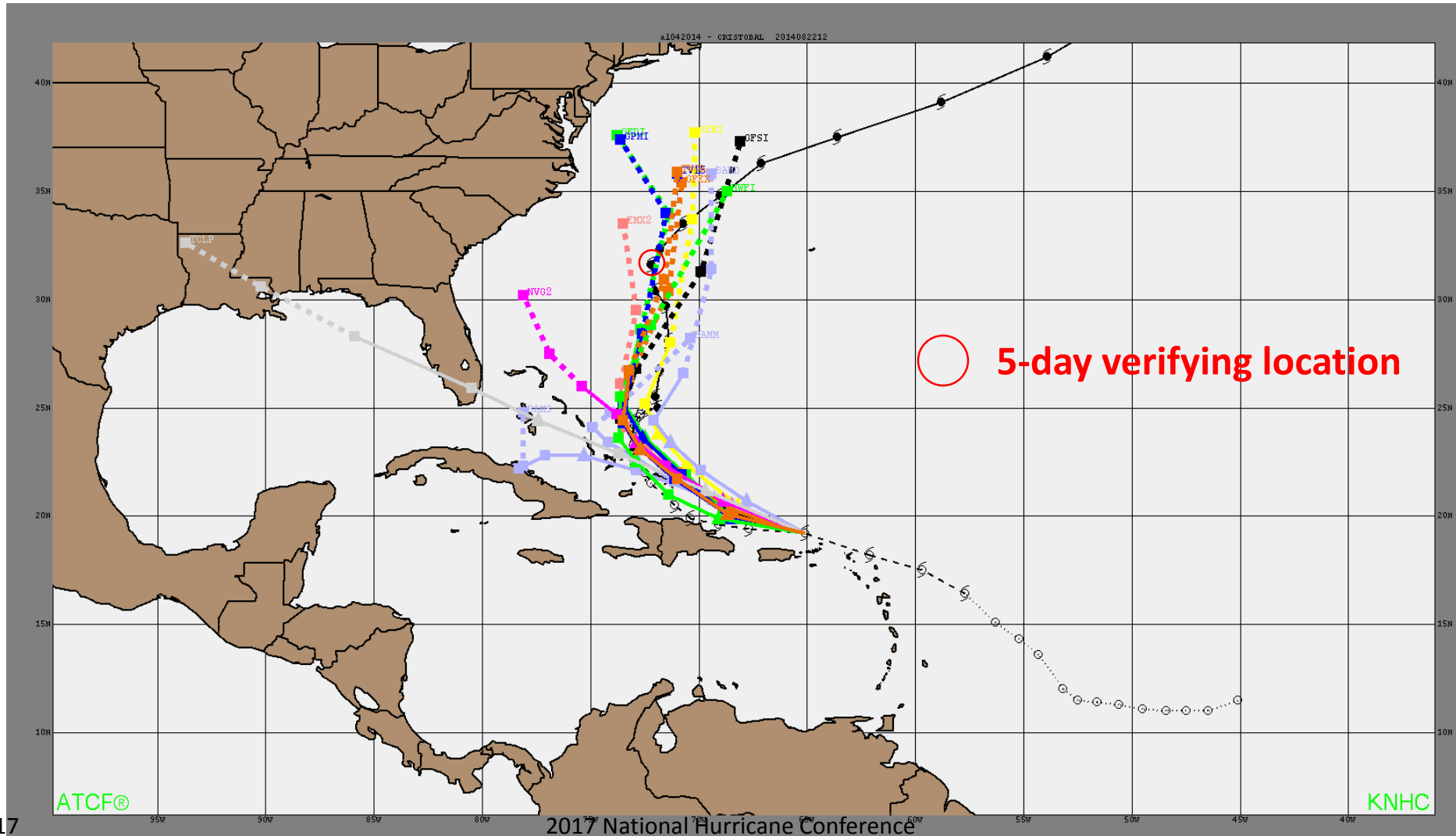






# Guidance for Invests

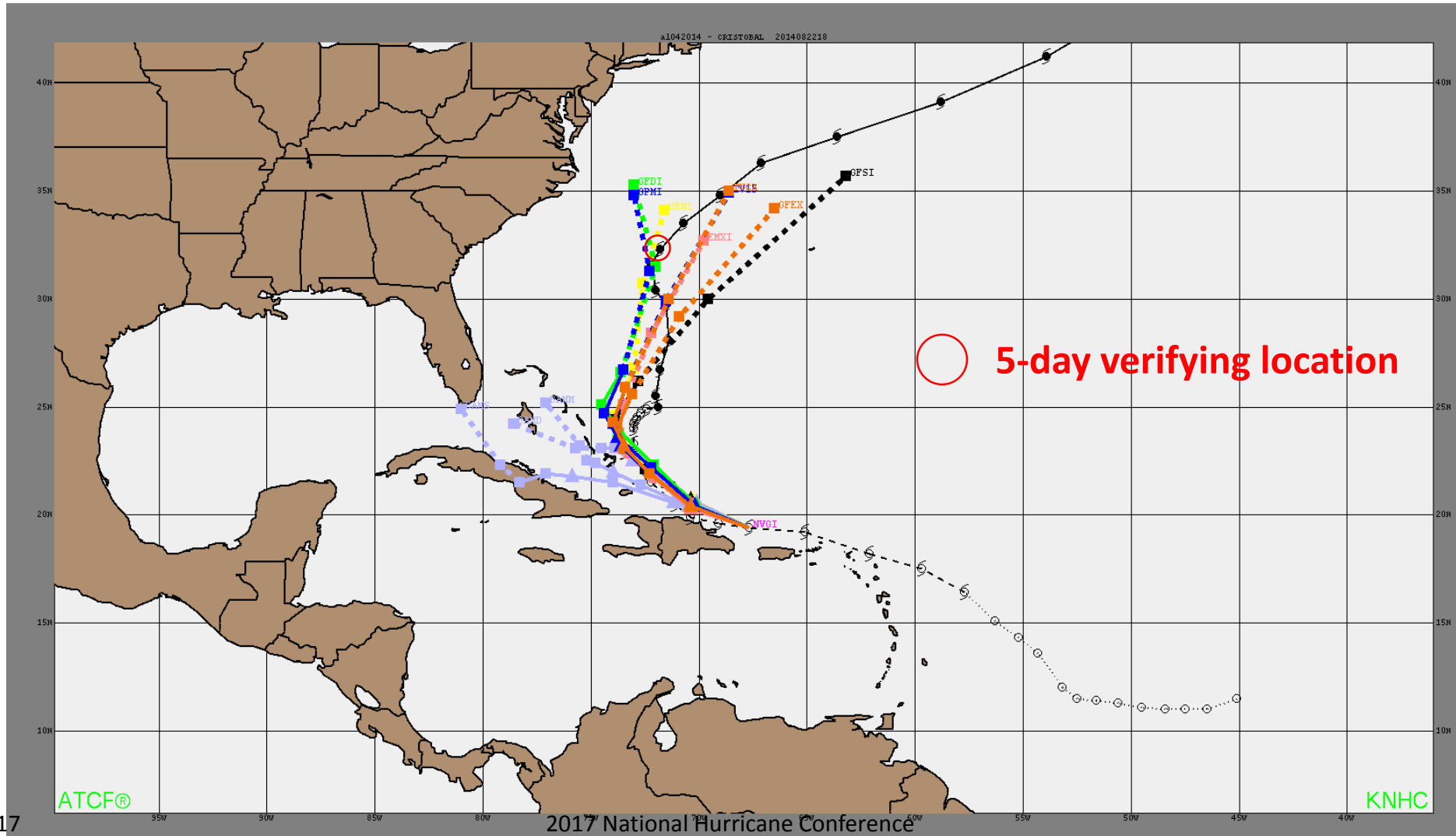
## *Pre-Cristobal – 12Z 22 Aug. 2014*





# Guidance for Invests

## *Pre-Cristobal – 18Z 22 Aug. 2014*

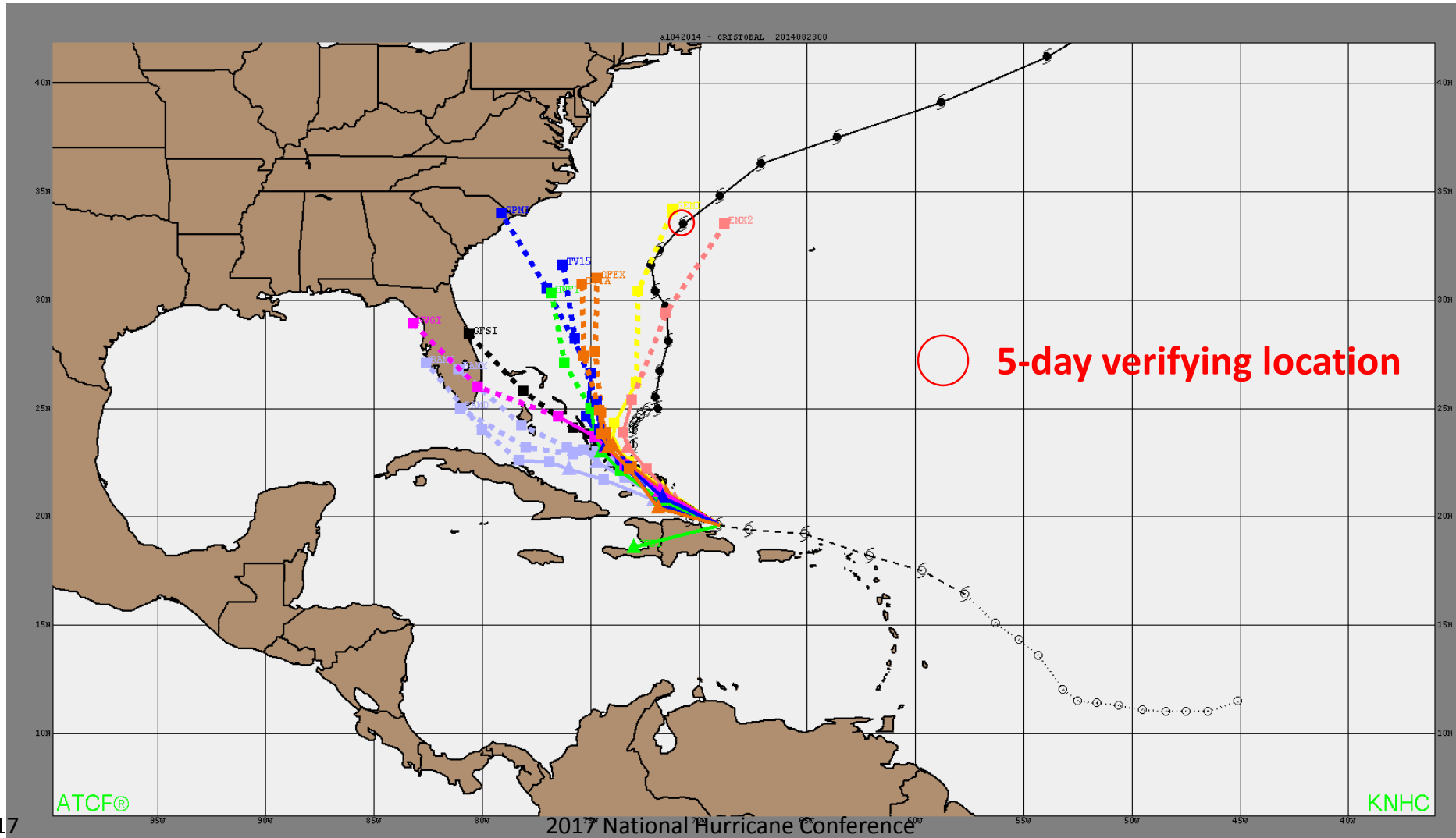






# Guidance for Invests

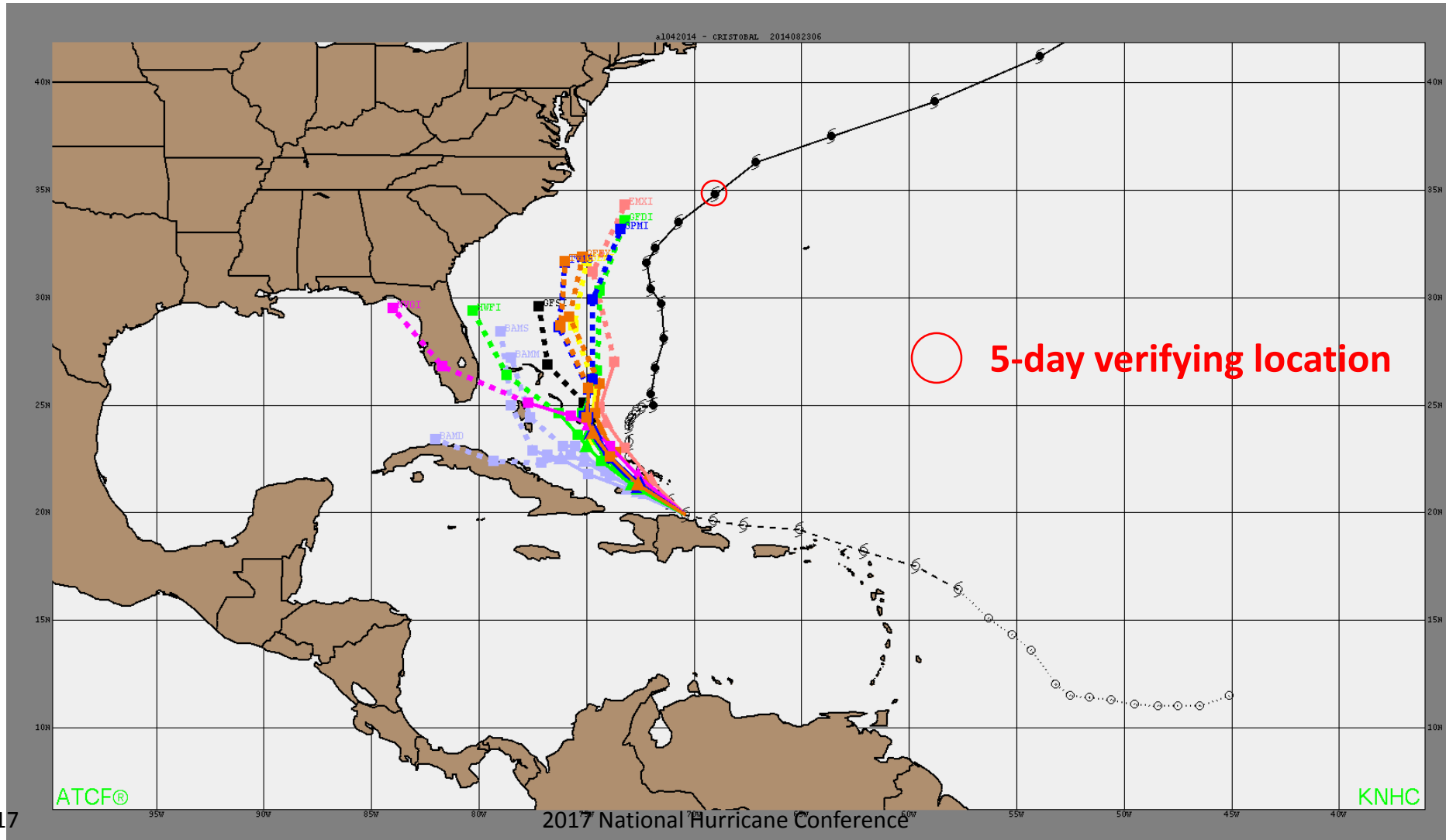
## *Pre-Cristobal – 00Z 23 Aug. 2014*





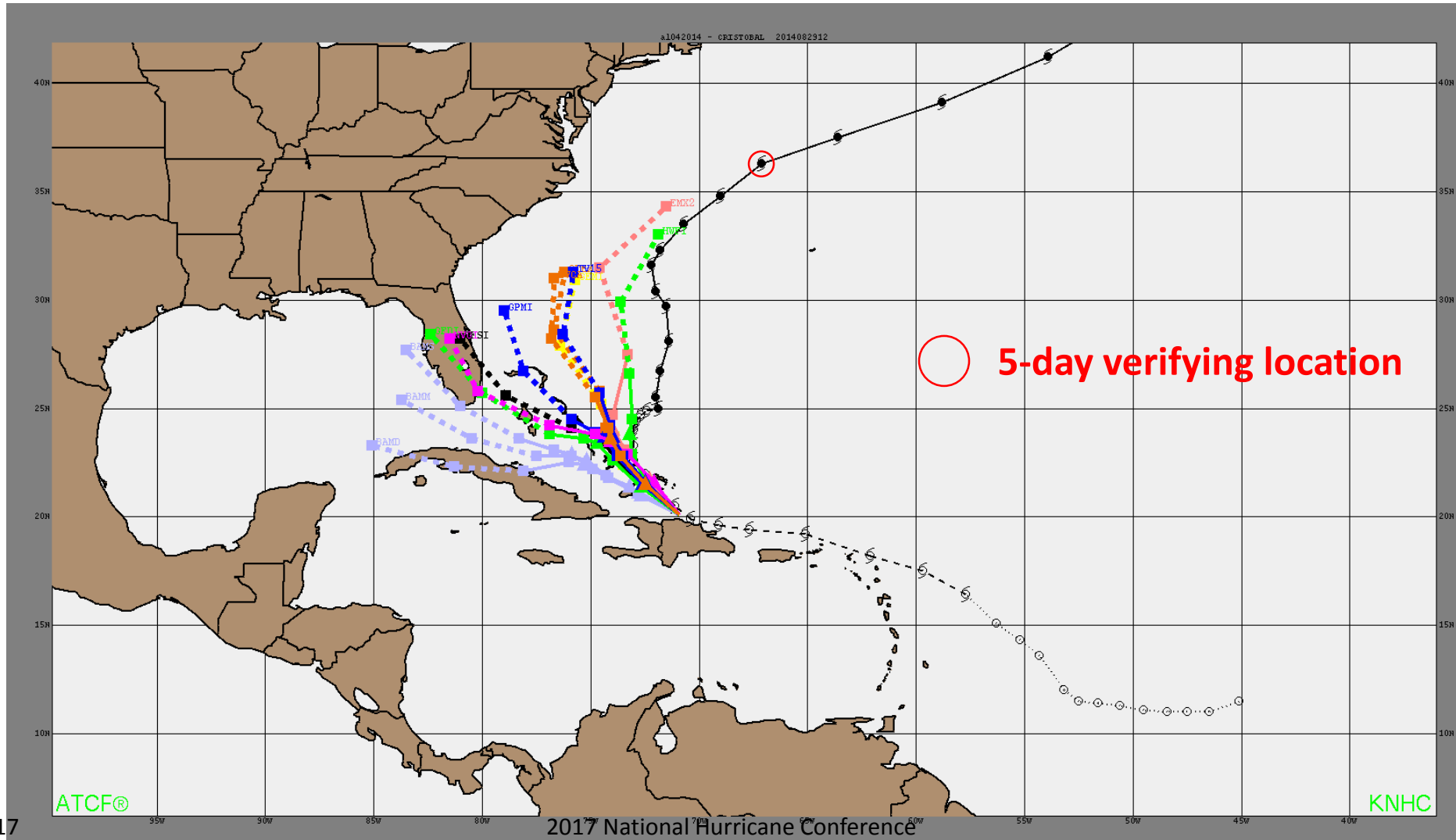
# Guidance for Invests

## *Pre-Cristobal – 06Z 23 Aug. 2014*



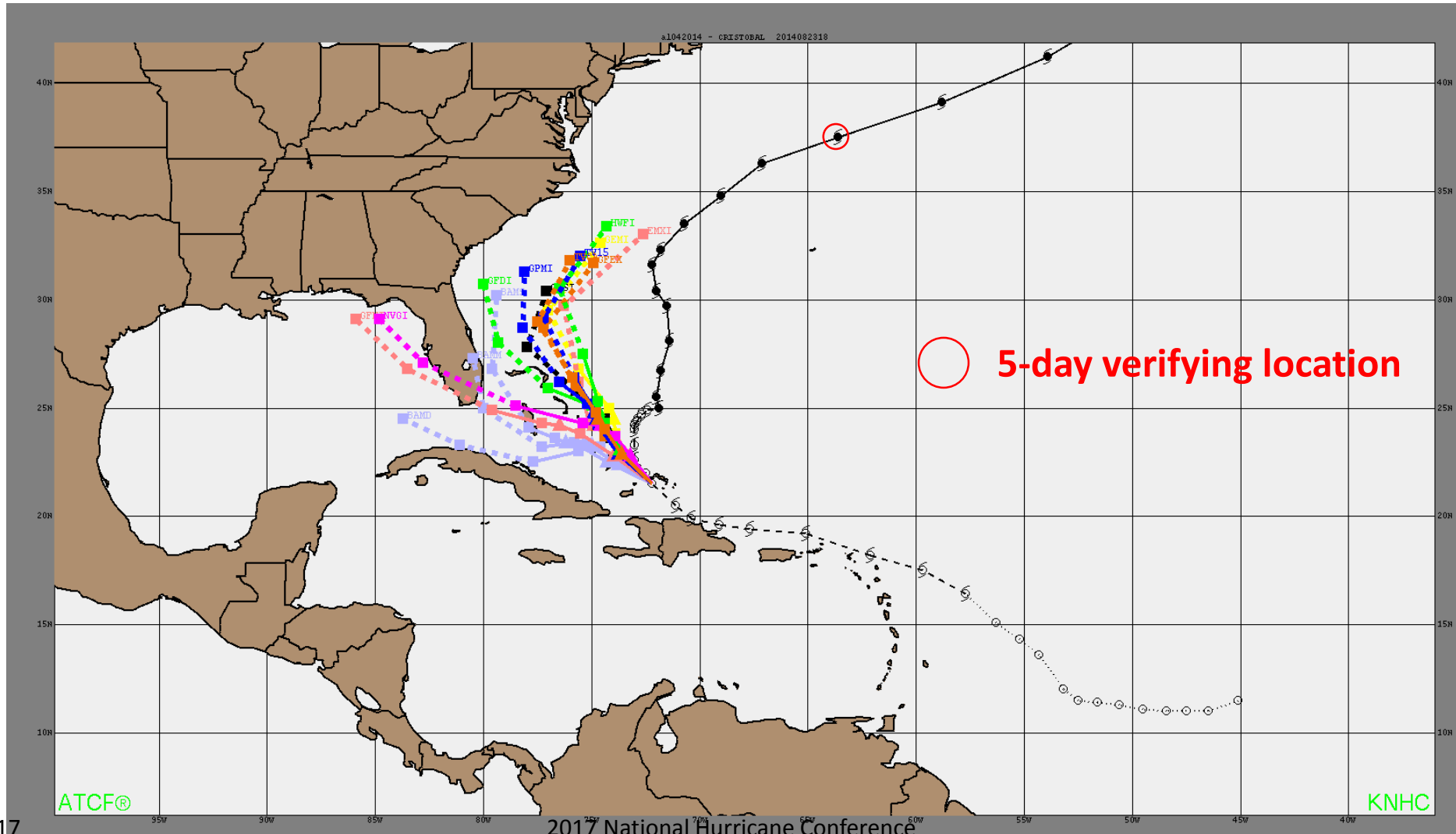
# Guidance for Invests

## Pre-Cristobal – 12Z 23 Aug. 2014



# Guidance for Invests

*Cristobal – 18Z 23 Aug. 2014 (first advisory)*



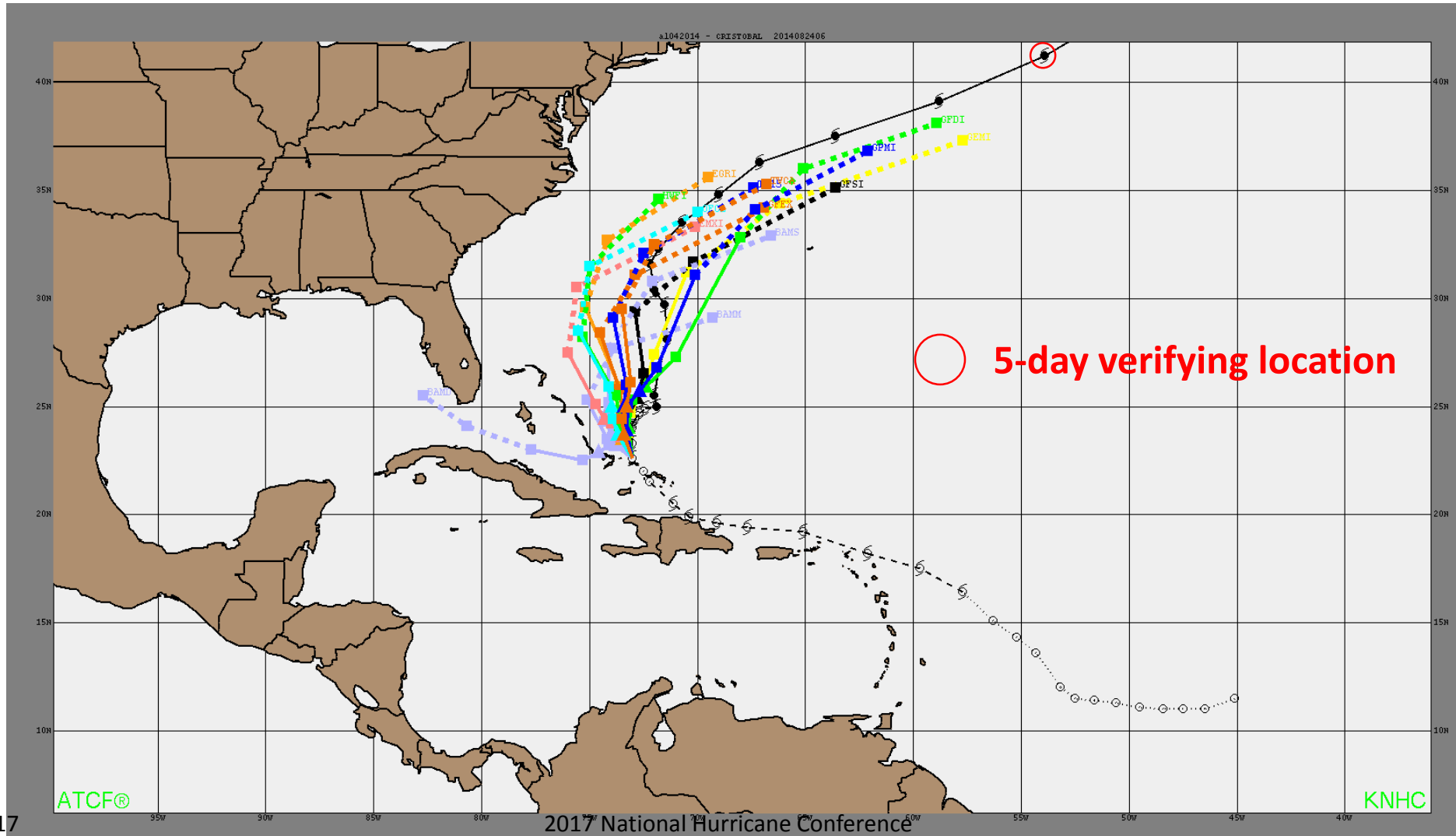






# Guidance for Invests

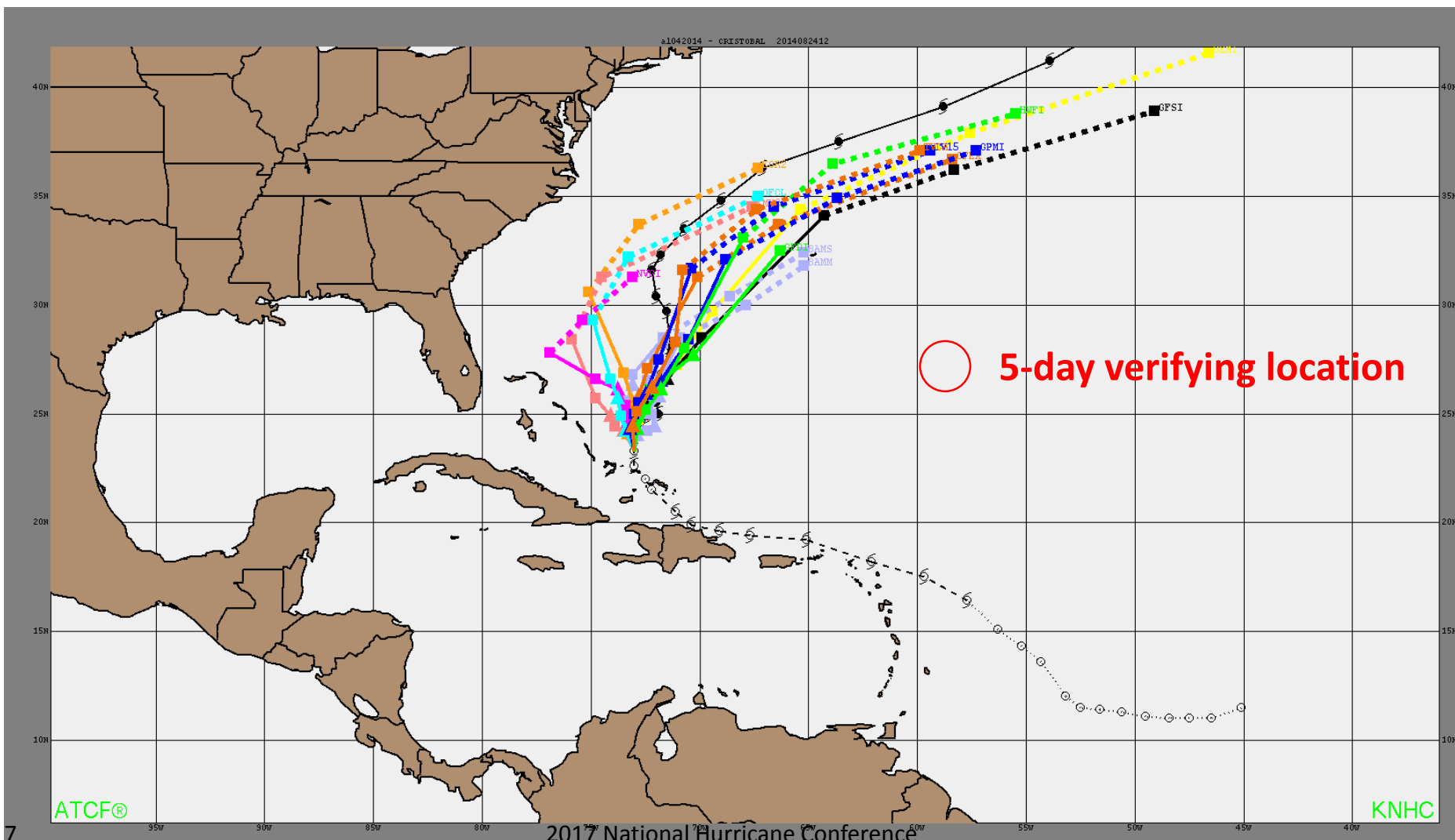
## *Cristobal – 06Z 24 Aug. 2014*



○ 5-day verifying location

# Guidance for Invests

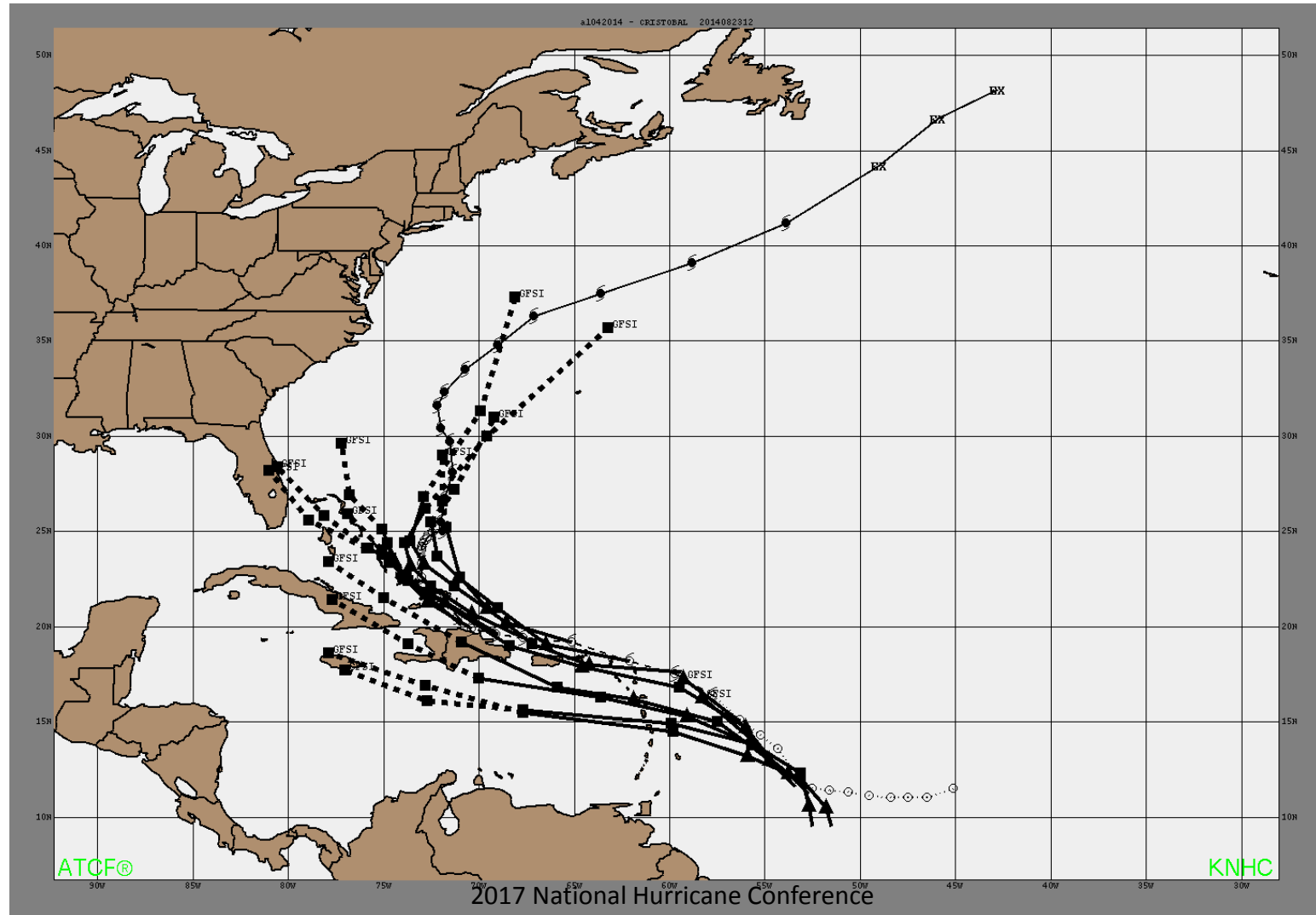
## *Cristobal* – 12Z 24 Aug. 2014





# Guidance for Invests

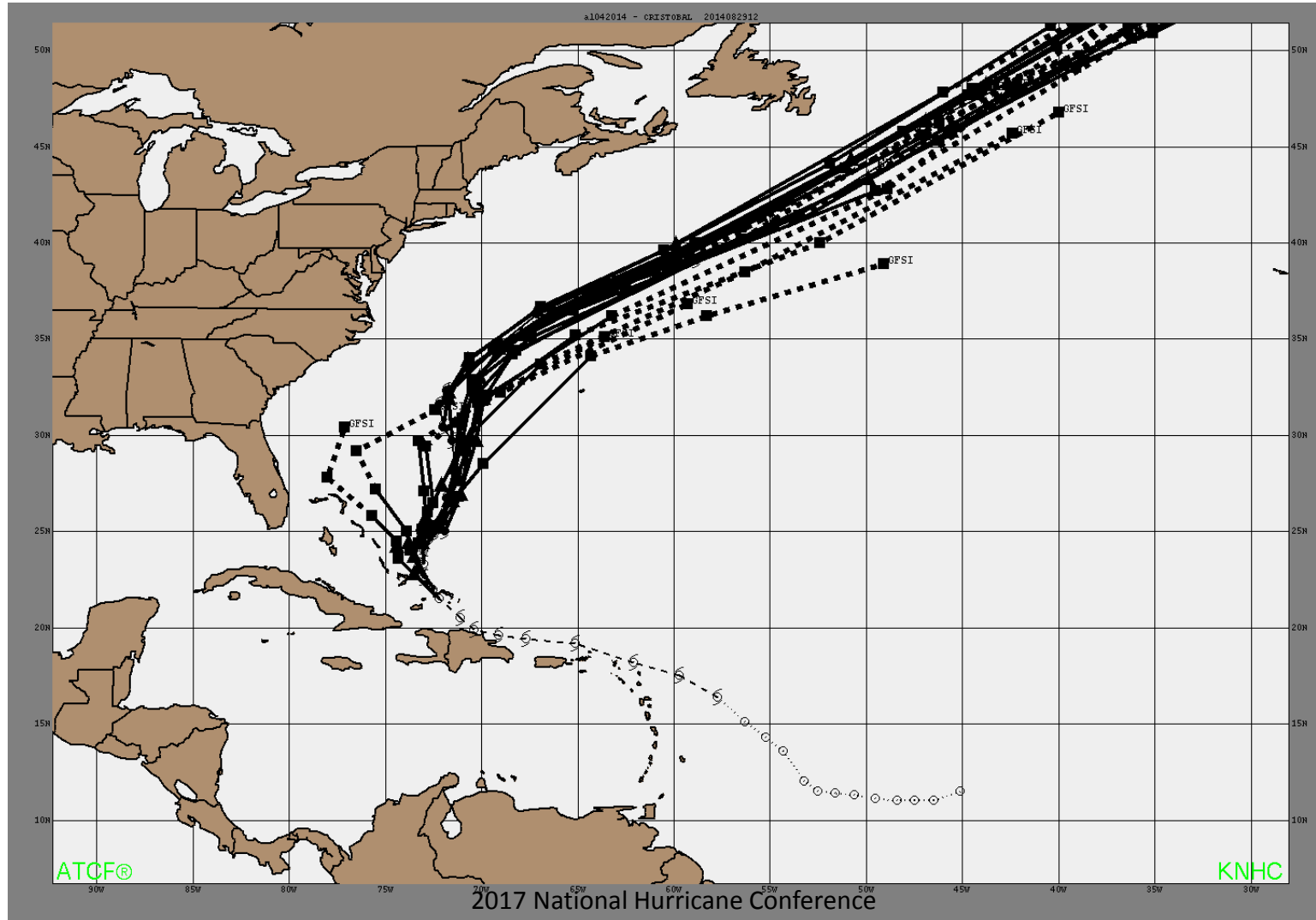
## *Cristobal – GFS Guidance Before Genesis*





# Guidance for Invests

## *Cristobal – GFS Guidance After Genesis*





# Intensity Guidance for Invests

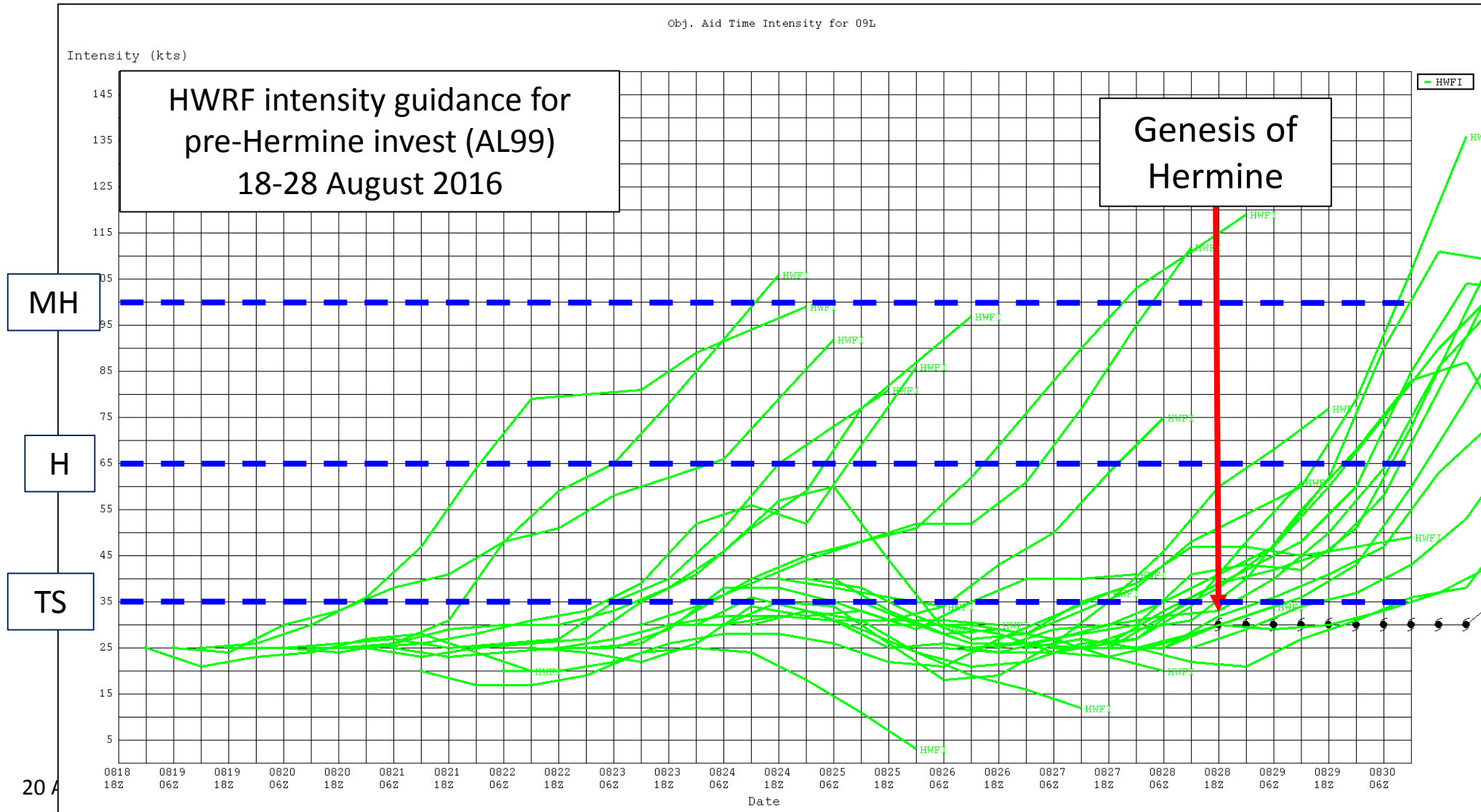
- Intensity guidance for invests can have several issues
- Statistical guidance (SHIPS, LGEM) assume that the system is already a tropical cyclone
  - Can often lead to over-development if system is weak and/or disorganized
- HWRF and HMON use the GFS analyzed vortex when initial intensity < 30 kt and use previous 6-h HWRF/HMON forecast first guess for stronger storms, with NHC provided initial intensity used to correct vortex intensity
  - HWRF also uses data assimilation and a composite storm in intensity correction for shallow systems (vortex only has structure below 500 mb)
  - HMON uses a composite storm in intensity correction for shallow or deep storms
- These procedures can lead to issues with improper structure and affect model intensity and structure forecasts





# Guidance for Invests

## *Pre-Hermine Intensity Guidance - HWRF*





# Guidance for Invests

## *Pre-Hermine Intensity Guidance - SHIPS*

