Tropical Cyclone Genesis Forecasting and Pre-Genesis Forecasts

Five-Day Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida

Meteorology Workshop 3 – Potential Tropical Cyclones
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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 ~5°
- Adequate ocean thermal energy
  - SST > 26°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
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.
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/GEFS ensemble product showing the probability of 850-200-mb shear < 20 kt and 850-700 mb RH > 70% with 850-mb relative vorticity contours
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
• 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

Tropical Weather Outlook

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

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Forecaster Avila

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

- Reason(s) for special outlook issuance provided
- New information provided for “Updated” disturbance
Special Tropical Weather Outlook
Issued for Significant or Unexpected Changes or

Reason(s) for special outlook issuance provided

New information provided for “Updated” disturbance

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
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

5-day verifying location
Guidance for Invests

Pre-Cristobal – 00Z 21 Aug. 2014

5-day verifying location
Guidance for Invests
Pre-Cristobal – 06Z 21 Aug. 2014

5-day verifying location
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

5-day verifying location
Guidance for Invests

*Pre-Cristobal – 06Z 22 Aug. 2014*
Guidance for Invests

Pre-Cristobal – 12Z 22 Aug. 2014

5-day verifying location
Guidance for Invests
Pre-Cristobal – 18Z 22 Aug. 2014

5-day verifying location
Guidance for Invests

Pre-Cristobal – 00Z 23 Aug. 2014
Guidance for Invests

Pre-Cristobal – 06Z 23 Aug. 2014

5-day verifying location
Guidance for Invests
Pre-Cristobal – 12Z 23 Aug. 2014
Guidance for Invests
Cristobal – 18Z 23 Aug. 2014 (first advisory)

5-day verifying location
Guidance for Invests

Cristobal – 00Z 24 Aug. 2014
Guidance for Invests


5-day verifying location
Guidance for Invests

Cristobal – 12Z 24 Aug. 2014

5-day verifying location
Guidance for Invests
Cristobal – GFS Guidance Before Genesis

20 April 2017
2017 National Hurricane Conference
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

HWRF intensity guidance for pre-Hermine invest (AL99) 18-28 August 2016

Genesis of Hermine
SHIPS model intensity guidance for pre-Hermine invest (AL99) 18-28 August 2016

Genesis of Hermine