### Forecasting at the National Hurricane Center Tokyo, March 2014





NOAA

Fecha: 24/10/2012 Hora local: 12:00 pm





### During Hurricanes....everybody becomes a specialist!







### National Hurricane Center Organizational Structure



### Hurricane Specialist Unit

Develop, coordinate (domestically and abroad), and issue tropical cyclone warnings, forecasts, and outlooks in text and graphical formats (~700 full advisory packages/yr)

"Off-season" outreach and public awareness programs

Applied research



Tropical Analysis and Forecast Branch

Marine/ocean and satellite analyses, forecasts and warnings in text and graphical formats, 24x7, (~100 products/day)

Conduct tropical cyclone (Dvorak) analyses for the hurricane specialists

Augments operational support staffing



### Technology and Science Branch

Computer systems support 24x7

Applications development and technology infusion

Storm surge guidance (real time; community planning; preparedness)

Emergency operational support staffing

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### NATIONAL HURRICANE CENTER



DASH - MATRIX MANAGED

### National Hurricane Center National Weather Service Miami Forecast Office



- Building opened 1995
- 25,000 square feet
- Design team included Herb Saffir
- 10-inch thick walls made from 3000 cubic yards of concrete, reinforced with 45 miles of steel reinforcing rods
- More than 50 miles of electrical and communications wiring
- Base rests five feet above flood plain



## Major NHC Milestones



- 1955: Regularly scheduled numerical model forecasts began
- 1961: 2-day tropical cyclone forecasts introduced
- 1964: 3-day tropical cyclone forecasts began
- **1980: NHC begins issuing all Atlantic advisories**
- 1988: NHC assumes responsibility for the E. Pacific
- mid 1990s: NHC web site developed and graphics produced
- 2001: Cone graphic introduced
- 2003: 4-day and 5-day forecasts began
- 2007: Graphical Tropical Weather Outlook first issued
- 2010: Tropical cyclone watch/warning lead times increased
- 2013: Tropical Weather Outlook expanded from 48 h to 5 days



### NHC Areas of Responsibility





# **Tropical Cyclone History** Data since 1949 in the Pacific, 1851 in the Atlantic









## National Hurricane Center Operations







# Sector NWS / DOD Coordination Call

### Coordinate and determine watches/ warnings















### Hurricane Liaison Team

### Media Interviews



### WORLD METEOROLOGICAL ORGANIZATION Regional Association IV (RA-IV) Coordination





### NHC Coordination of International Watches & Warnings



- Each country is responsible for issuing watches/warning for their respective country or jurisdiction
  - NHC issues watches/warnings for Haiti
- NHC will recommend the placement of watches/warnings
- Coordinated via phone with Met. Offices throughout the region
- Tropical Storm or Hurricane Watches and Warnings are currently not issued prior to the formation of a tropical depression





Tropical Cyclone Breakpoints - Caribbean



### Hurricane Dean watches and warnings

## **RA-IV Hurricane Committee**



### WORLD METEOROLOGICAL ORGANIZATION TECHNICAL DOCUMENT

TROPICAL CYCLONE PROGRAMME Report No. TCP-30

Regional Association IV (North and Central America and the Caribbean) Hurricane Operational Plan)

2013 Edition

SECRETARIAT OF THE WORLD METEOROLOGICAL ORGANIZATION – GENEVA SWITZERLAND

World Meteorological Organization 2013



## The "Offseason"







L-0311 at Nat. Hurr. Conference



World Meteorological Course For International Meteorologists



State L-0320 Course

Plus two National Weather Service Training Courses in 2014! **No- The Outreach and** Education Season!!!





Three L-0324 Courses at NHC

# NHC Outreach and Education



"Battle is won (or lost) during the off-season..."

Highlights of annual NHC involvement with federal partners and Caribbean countries:

- National Hurricane Conference
- World Meteorological Organization workshop for international meteorologists (2-week course at NHC)
- Caribbean Hurricane Awareness Tour
- National Hurricane Preparedness Week
- 5 FEMA sponsored emergency management evacuation decision making training courses
- U.S. Interdepartmental Hurricane Conference
- State Hurricane Conferences



### WMO RA-IV WORKSHOP ON HURRICANE FORECASTING AND WARNING



# International Collaboration Highlights

HEATHUR GERVIC

- Open exchange of meteorological data among countries
- NHC provides forecasts and guidance on watches and warnings to 30 WMO member nations
- NHC hosts and teaches two-week workshop on tropical cyclones for international government meteorologists.
- NHC Director serves as Chairman of the WMO RA-IV Hurricane Committee.
   Annual meeting updates the Region's "Hurricane Operational Plan"
- U.S. conducts annual Caribbean Hurricane
  Awareness Tour





# The battle is won outside the hurricane season





# National Hurricane Center and Weather Forecast Office Products





## NHC Tropical Cyclone Products





NHC provides the "big picture" that complements and guides local NWS forecast office products, and provides guidance for international partners

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# NHC Text Products



- Public Advisory
- Forecast Advisory
- Forecast Discussion
- Wind Speed Probabilities
- > Tropical Cyclone Update
- Tropical Weather Outlook \*\*\*\*\*
- Tropical Cyclone Reports
- Monthly Tropical Weather Summary



# NHC Graphical Products

WEATHER SERVICE

- > Track Forecast Cone
- Surface Wind Field
- Surface Wind Speed Probabilities
- > Cumulative Wind History
- > Graphical Tropical Weather Outlook
- Storm Surge Probabilities
- > Podcasts (Audio)







## Public Advisory

Plain-language text product originally intended for "rip and read".

- Headline or lead statement
- Watches and warnings
- Center location, motion, forecast
- Wind speed and forecast
- Storm surge, rainfall, tornadoes, and generalized timing of wind arrival
- Tornadoes
- Recommended actions







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STORM SURGE...AN EXTREMELY DANGEROUS STORM SURGE WILL RAISE WATER LEVELS BY AS MUCH AS 6 TO 11 FEET ABOVE GROUND LEVEL IN THE HURRICANE WARNING AREA IN NORTH CAROLINA...INCLUDING THE ALBEMARLE AND PAMLICO SOUNDS. STORM SURGE WILL RAISE WATER LEVELS BY AS MUCH AS 4 TO 8 FEET ABOVE GROUND LEVEL WITHIN THE HURRICANE WARNING AREA FROM THE NORTH CAROLINA/VIRGINIA BORDER NORTHWARD TO CAPE COD INCLUDING SOUTHERN PORTIONS OF THE CHESAPEAKE BAY AND ITS TRIBUTARIES. NEAR THE COAST...THE SURGE WILL BE ACCOMPANIED BY LARGE...DESTRUCTIVE...AND LIFE-THREATENING WAVES. STORM SURGE VALUES ARE VERY LOCATION-SPECIFIC...AND USERS ARE URGED TO CONSULT PRODUCTS ISSUED BY THEIR LOCAL NATIONAL WEATHER SERVICE OFFICES.

RAINFALL...IRENE IS EXPECTED TO PRODUCE RAINFALL ACCUMULATIONS OF 6 TO 10 INCHES...WITH ISOLATED MAXIMUM AMOUNTS OF 15 INCHES...FROM EASTERN NORTH CAROLINA NORTHWARD THROUGH THE MID-ATLANTIC STATES INTO NEW ENGLAND THROUGH MONDAY MORNING. THESE RAINS COULD CAUSE WIDESPREAD FLOODING AND LIFE-THREATENING FLASH FLOODS.

SURF...LARGE SWELLS GENERATED BY IRENE ARE AFFECTING PORTIONS OF THE COAST OF THE SOUTHEASTERN UNITED STATES. THESE SWELLS WILL CAUSE LIFE-THREATENING SURF AND RIP CURRENT CONDITIONS.

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# Intermediate

## Public Advisory

- Provides continuous flow of information
- Issued when watches or warnings are in effect
- Issued 3-hourly or 2-hourly if welldefined center within NWS radar range
- Not used to issue watches or warnings
- Content similar to routine public advisories







## Forecast Advisory

- Only source of all the forecast data
- Data is used in HURREVAC and other commercial tracking software
- Watches and warnings
- Center location, motion, minimum pressure, and eye diameter
- Forecast positions, intensity, and wind radii





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| Dum Humog      PORECAST BODR      Date Date      State      State <thstate< th="">      State      State<!--</td--><td>Nume      TOURCAST HOUR      Date      Def      Junit      1sz      24      36      1sz      96      MON      Def      TOUR      Def      TOUR      Def      MON      MON</td><td>-</td><td>-10-</td></thstate<>  | Nume      TOURCAST HOUR      Date      Def      Junit      1sz      24      36      1sz      96      MON      Def      TOUR      Def      TOUR      Def      MON  | -          | -10-   |
| Definite      Dissification      24      36      48      56      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      62      100      10      10      7      36      36      36      36      37      36      37      36      37      37      36      32      37      43   | Define      Dissipate      24      36      48      72      85      76      96      76      96      77      76      44      37      20      7      76      76      77      76      76      77      76      76      77      76      76      77      76      76      77      76      77      76      77      76      77      76      77      77      76   |            |  |
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| Withing      Mix (AT 2)      7      17      32      9      6      5      2        Within      Num (AT 3)      7      6      1      1      5      2        Within      Num (AT 3)      7      2      1      1      1      2        Within      Num (AT 3)      7      2      2      1      1      2        Within      Num (AT 3)      X      X      X      X      X      X        Within 10      Total      X      X      X      X      X      X   | III QUBRIONE THE 67  | 3 1        |  |
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| STAT STAT  | anch 75kT 70KT 65MT 50kT   | x          |  |

### Wind Speed Probabilities

- Depicts location-specific probabilities of tropical-stormforce, 50 kt, and hurricane-force winds.
- Contains cumulative and individual time period onset probabilities for a fixed set of locations







## **Forecast Discussion**

- Free-form text product
- Provides the reasoning behind forecasts and warnings
- Discussion of relevant observations, model guidance, and the forecast uncertainties
- Includes table of track and intensity forecasts














### NHC Tropical Cyclone Advisory Products







### NHC Tropical Cyclone Advisory Products





<u>Cumulative</u> Wind History

Shows:

Areas potentially affected so far by sustained winds of tropical storm force (in orange) and hurricane force (in red).



### Tropical Cyclone Update



TROPICAL STORM CLAUDETTE TROPICAL CYCLONE UPDATE NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL042009 1215 PM EDT SUN AUG 16 2009

...DEPRESSION BECOMES TROPICAL STORM CLAUDETTE...

DATA FROM THE NOAA DOPPLER RADAR IN TALLAHASSEE FLORIDA INDICATE THAT SURFACE WINDS ASSOCIATED WITH THE DEPRESSION HAVE INCREASED TO 40 MPH...65 KM/HR...MAKING THE DEPRESSION TROPICAL STORM CLAUDETTE.

....SUMMARY OF 1215 PM AST INFORMATION... LOCATION...28.7N 84.6W MAXIMUM SUSTAINED WINDS...40 MPH PRESENT MOVEMENT...NORTHWEST OR 320 DEGREES AT 14 MPH MINIMUM CENTRAL PRESSURE...1011 MB \$\$

### FORECASTER ROBERTS/BRENNAN

This product is issued when: (1) cyclone makes landfall (2) unexpected changes occur in the cyclone (3) to issue international watches and warnings (4) for 1-hourly position estimates when system with eye is nearing land





Timeline for Advisories/Updates -No Watches/Warnings

## Eastern Daylight Time

- 5 am- Advisory
- 11 am Advisory
- 5 pm- Advisory
- 11 pm- Advisory



### Other NHC Tropical Cyclone Related Products



ABNT30 KNHC 011156 TWSAT MONTHLY TROPICAL WEATHER SUMMARY NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL 800 AM EDT FRI OCT 01 2010

FOR THE NORTH ATLANTIC ... CARIBBEAN SEA AND THE GULF OF MEXICO ...

EIGHT TROPICAL STORMS FORMED IN THE ATLANTIC BASIN DURING THE MONTH OF SEPTEMBER. THREE OF THESE STORMS...IGOR...JULIA...AND KARL... BECAME MAJOR HURRICANES...AND LISA REACHED HURRICANE STATUS. THESE NUMBERS ARE WELL ABOVE THE LONG-TERM (1944-2009) AVERAGES OF 4 TROPICAL STORMS...2 HURRICANES...AND ABOUT 1 MAJOR HURRICANE FOR THE MONTH OF SEPTEMBER. ALSO...THE FORMATION OF EIGHT NAMED STORMS TIES 2002 FOR THE RECORD NUMBER OF NAMED STORMS FORMING IN THE MONTH OF SEPTEMBER. IN TERMS OF ACCUMULATED CYCLONE ENERGY... ACE...WHICH MEASURES THE COMBINED STRENGTH AND DURATION OF TROPICAL STORMS AND HURRICANES...TROPICAL CYCLONE ACTIVITY IN SEPTEMBER WAS ABOUT 78 PERCENT ABOVE AVERAGE.

SO FAR THIS SEASON...OVERALL TROPICAL CYCLONE ACTIVITY TO DATE IS ABOUT 53 PERCENT ABOVE THE LONG-TERM MEDIAN.

REPORTS ON INDIVIDUAL CYCLONES...WHEN COMPLETED...ARE AT THE WEB SITE OF THE NATIONAL HURRICANE CENTER...USE LOWER-CASE LETTERS...HTTP://WWW.NHC.NOAA.GOV/2010ATLAN.SHTML

#### SUMMARY TABLE

| NAME             |          | DATES |       |     | MAX | WIND | (MPH) |
|------------------|----------|-------|-------|-----|-----|------|-------|
| н                | ALEX     | 25    | JUN-2 | JUL |     | 105  |       |
| TD               | TWO      |       | 7-8   | JUL |     | 35   |       |
| TS               | BONNIE   |       | 22-24 | JUL |     | 40   |       |
| TS               | COLIN    |       | 2-8   | AUG |     | 60   |       |
| $^{\mathrm{TD}}$ | FIVE     |       | 10-11 | AUG |     | 35   |       |
| MH               | DANIELLE |       | 21-31 | AUG |     | 135  |       |
| MH               | EARL     | 25    | AUG-5 | SEP |     | 145  |       |
| TS               | FIONA    | 30    | AUG-4 | SEP |     | 60   |       |
| TS               | GASTON   |       | 1-2   | SEP |     | 40   |       |
| TS               | HERMINE  |       | 6-8   | SEP |     | 65   |       |
| MH               | IGOR     |       | 8-21  | SEP |     | 155  |       |
| MH               | JULIA    |       | 12-20 | SEP |     | 135  |       |
| MH               | KARL     |       | 14-18 | SEP |     | 120  |       |
| Н                | LISA     |       | 21-26 | SEP |     | 80   |       |

# Tropical Weather

**Summary** 

- Issued on the first of each month from July-Dec
- Summarizes tropical cyclones that occurred during the previous month
- Provides preliminary statistics of the season thus far



### Other NHC Tropical Cyclone Related Products





### Preliminary Track Maps

- Posted to NHC
  website around the
  1<sup>st</sup> of each month
  Provides preliminary
- tracks of the season's tropical cyclones to date
- Operational track & intensities shown until final "besttrack" issued



## Other NHC Tropical Cyclone Related Products







## Possible Future Enhancements to NHC Forecast Products

### Expected changes in 2014



- New 5-day Graphical Tropical Weather Outlook
   Changes to the 48-hour Graphical Outlook
- Elimination of the Maximum Intensity Probability Table
- Storm Surge Inundation Graphic will be available
- Mixed case text in the Tropical Weather Outlook and Tropical Cyclone Discussion

### Current NHC In-house Experiments

- Storm Surge Warning (2015)
- Extension of tropical cyclone forecasts to 7 days
- Watches and warnings before formation
- Track and intensity forecasts for disturbances



# **Tropical Weather Outlook**



- General assessment of activity in the tropics, pertaining to tropical cyclone formation
- Discusses areas of disturbed weather and their potential for formation (into a tropical cyclone) during the <u>next 5 days</u>
- Chance of formation during the first 48 hours and entire 5-day period are provided

Issued at 2 AM, 8 AM, 2 PM, 8 PM EDT During EST issuance times become-1 AM, 7 AM, 1 PM, 7 PM





Tropical or Sub-Tropical Cyclone: O Depression O Storm D Hurricane Post-Tropical Cyclone: O < 39 mph O 39-73 mph O > 73 mph X Remnants

Chance of Formation: □Low < 30% ■Medium 30-50% ■ High > 50% X indicates current disturbance location; shading indicates potential formation area





# Guidance

### Large-Scale Conditions and Other Characteristics Associated with TC Formation

### **Necessary but not sufficient conditions**

- A pre-existing disturbance containing abundant deep convection
- Latitudes poleward ~5°
- Adequate ocean thermal energy

- SST > 26°C extending to a depth of 60 m

- A "sufficiently" unstable atmosphere & deep layer of moist air
- Small vertical shear of the horizontal wind

### Large-Scale Conditions and Other Characteristics Associated with TC Formation (cont'd)

- 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

"We observe universally that tropical storms form only within pre-existing disturbances...An initial disturbance therefore forms part of the starting mechanism. A weak circulation, low pressure and a deep moist layer are present at the beginning. The forecaster need not look into areas which contain no such circulations."

Herbert Riehl (1954)

### MADDEN-JULIAN OSCILLATION: RELATED TO INTRASEASONAL VARIABILITY IN TC ACTIVITY?

Composite evolution of 200hPa velocity potential anomalies (10<sup>5</sup> x m<sup>2</sup>/s) and points of origin of tropical systems that developed into hurricanes/typhoons





200 MB VELOCITY POTENTIAL 5°N-5°S 5-DAY RUNNING MEAN Links for analyses of the MJO (from the Climate Prediction Center):

http://www.cpc.ncep.noaa.gov/products/p recip/CWlink/MJO/mjo.shtml

Also:

http://www.cpc.ncep.noaa.gov/products/h urricane/vpot\_tlon.shtml

### Objective Guidance Tools for Forecasting TC Genesis

- Global models can depict TC formation even in complex cases fairly realistically
- GFS and ECMWF continue to be the most useful; consensus of these 2 models has a low false alarm rate
- Problems (again) forecasting genesis in subtropics (e.g. Chris, Michael) disturbances of non-tropical origin
- Although deterministic models are relied on more than the ensembles, the latter guidance often is more consistent and can help resolve run to run changes of the former
- Models may change, to some degree, annually so forecasters accustomed to a model's performance in one season will have to reacquaint himself/herself with the new model each season
- A genesis parameter which combines 850-mb circulation, shear, instability, and moisture has shown some promise for anticipating TC formation.

### **Criteria for model Genesis**

- At initial time: (real world)
  - No closed isobars
  - No organized cloud pattern (unclassifiable by the Dvorak Technique)
- Forecast (3-5 days out):
  - Low pressure persists through forecast period
  - Reasonable spatial and temporal scale
  - At least one closed isobar (at 4 mb interval) with lowered central pressure
  - Reasonable structure (warm core, deep vertical extent)
  - NHC issued advisories (verification)

### TC Genesis Forecasting at the NHC:

- Primary numerical guidance comes from global models
- GFS and ECMWF seem to have greatest skill, but more systematic verification is needed
- Models appear to have some geographical biases, and seem to do better when large-scale influences are the dominant mechanism (e.g. monsoonal flow near western Africa)
- Considerable subjectivity involved in NHC genesis forecasts
- Genesis forecasts are more problematic in Gulf of Mexico since models have difficulty depicting genesis in that region (smaller-scale processes play a bigger role?)





# Examples and Challenges





TROPICAL WEATHER OUTLOOK NWS NATIONAL HURRICANE CENTER MIAMI FL 200 AM EDT FRI SEP 6 2013

FOR THE NORTH ATLANTIC ... CARIBBEAN SEA AND THE GULF OF MEXICO ...

THE NATIONAL HURRICANE CENTER HAS ISSUED THE LAST ADVISORY ON TROPICAL DEPRESSION GABRIELLE WHICH DISSIPATED NEAR THE DOMINICAN REPUBLIC.

1. A BROAD AREA OF LOW PRESSURE IN THE WESTERN GULF OF MEXICO LOCATED A LITTLE LESS THAN A HUNDRED MILES EAST OF TAMPICO IS MOVING WESTWARD. THIS SYSTEM IS ACCOMPANIED BY A LARGE BUT DISORGANIZED AREA OF CLOUDINESS AND A FEW SQUALLS. ALTHOUGH THE SYSTEM IS ALREADY APPROACHING LAND...A TROPICAL DEPRESSION COULD FORM BEFORE THE LOW MOVES INLAND ALONG THE COAST OF MEXICO LATER THIS MORNING. THIS SYSTEM HAS A MEDIUM CHANCE...50 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A MEDIUM CHANCE...50 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. REGARDLESS OF TROPICAL CYCLONE FORMATION...HEAVY RAIN AND GUSTY WINDS WILL BE SPREADING ALONG THE COAST OF THE MEXICAN STATES OF VERACRUZ AND TAMAULIPAS TODAY.

FORECASTER AVILA

### Another formation near the coast (TS Fernand)

#### August 24 800 PM

A LOW PRESSURE AREA ASSOCIATED WITH A TROPICAL WAVE LOCATED OVER THE WESTERN YUCATAN PENINSULA IS ACCOMPANIED BY A LARGE AREA OF CLOUDINESS AND THUNDERSTORMS. THIS DISTURBANCE IS FORECAST TO MOVE TOWARD THE WEST-NORTHWEST TONIGHT AND SUNDAY ACROSS THE SOUTHERN BAY OF CAMPECHE...WHERE ENVIRONMENTAL CONDITIONS APPEAR TO BE FAVORABLE FOR SOME DEVELOPMENT. THIS SYSTEM HAS A MEDIUM CHANCE...50 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A MEDIUM CHANCE...50 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. AN AIR FORCE PLANE IS SCHEDULED TO INVESTIGATE THE SYSTEM ON SUNDAY AFTERNOON...IF NECESSARY. WHETHER TROPICAL CYCLONE FORMATION OCCURS OR NOT...THIS DISTURBANCE IS LIKELY TO MOVE INLAND OVER THE STATE OF VERACRUZ MEXICO IN A COUPLE OF DAYS.



ALVARADO MEXICO RADAR IMAGE OF TROPICAL STORM FERNAND AT 0445 UTC 26 AUGUST NEAR LANDFALL ALONG THE COAST OF MEXICO. IMAGE COURTESY OF THE NATIONAL METEOROLOGICAL SERVICE OF MEXICO.





Maval Research Lab http://www.nrlmry.navy.mil/sat\_products.html <-- Visible ( Sum elevation at center is 73 degrees) -->





Genesis of small systems



TROPICAL WEATHER OUTLOOK NWS NATIONAL HURRICANE CENTER MIAMI FL 800 PM EDT SUN SEP 2 2012

FOR THE NORTH ATLANTIC...CARIBBEAN SEA AND THE GULF OF MEXICO...

A SMALL LOW PRESSURE AREA LOCATED ABOUT 1150 MILES NORTHWEST OF THE CAPE VERDE ISLANDS IS PRODUCING DISORGANIZED SHOWERS AND THUNDERSTORMS. UPPER-LEVEL WINDS ARE EXPECTED TO REMAIN UNFAVORABLE FOR SIGNIFICANT DEVELOPMENT...AND THIS SYSTEM HAS A LOW CHANCE...10 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS.

ELSEWHERE...TROPICAL CYCLONE FORMATION IS NOT EXPECTED DURING THE NEXT 48 HOURS.

\$\$ FORECASTER PASCH



#### Graphical Tropical Weather Outlook

National Hurricane Center Miami, Florida



Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <30%

Medium 30-50%

High >50%

ZCZC MIATWOEP ALL TTAA00 KNHC DDHHMM

TROPICAL WEATHER OUTLOOK NWS NATIONAL HURRICANE CENTER MIAMI FL 1100 AM PDT SAT SEP 7 2013

FOR THE EASTERN NORTH PACIFIC ... EAST OF 140 DEGREES WEST LONGITUDE ..

THE NATIONAL HURRICANE CENTER IS ISSUING ADVISORIES ON TROPICAL DEPRESSION LORENA...WHICH IS LOCATED JUST WEST OF THE SOUTHERN BAJA CALIFORNIA PENINSULA.

TROPICAL CYCLONE FORMATION IS NOT EXPECTED DURING THE NEXT 48 HOURS.

OTHER SYSTEMS WITH FORMATION POTENTIAL BEYOND 48 HOURS ...

A LOW PRESSURE AREA IS EXPECTED TO FORM SOUTH OF THE COAST OF MEXICO EARLY NEXT WEEK...AND CONDITIONS APPEAR CONDUCIVE FOR SOME DEVELOPMENT. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT FIVE DAYS.

&&

FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2013. COMMENTS ON THE EXPERIMENTAL FORECASTS CAN BE PROVIDED AT...

HTTP://WWW.NWS.NOAA.GOV/SURVEY/NWS-SURVEY.PHP?CODE=ETWO

\$\$ FORECASTER BEVEN NNNN



Graphical Tropical Weather Outlook National Hurricane Center Miami, Florida



Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <30% Medium 30-50% High >50%

TROPICAL WEATHER OUTLOOK NWS NATIONAL HURRICANE CENTER MIAMI FL 1100 AM PDT WED SEP 11 2013

FOR THE EASTERN NORTH PACIFIC...EAST OF 140 DEGREES WEST LONGITUDE.

A BROAD AREA OF LOW PRESSURE HAS FORMED JUST SOUTH OF THE GULF OF TEHUANTEPEC. THE LOW IS ACCOMPANIED BY DISORGANIZED CLOUDINESS AND THUNDERSTORMS AND IS FORECAST TO MOVE LITTLE DURING THE NEXT FEW DAYS. THIS DISTURBANCE HAS A LOW CHANCE...10 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. **REGARDLESS OF DEVELOPMENT...THIS SYSTEM IN COMBINATION WITH ANOTHER DISTURBANCE EXPECTED TO BE IN THE BAY OF CAMPECHE...WILL BRING HEAVY RAINS TO PORTIONS OF EASTERN MEXICO FOR THE NEXT SEVERAL DAYS.** 

FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2013. COMMENTS ON THE EXPERIMENTAL FORECASTS CAN BE PROVIDED AT...

HTTP://WWW.NWS.NOAA.GOV/SURVEY/NWS-SURVEY.PHP?CODE=ETWO

FORECASTER AVILA



Tropical Cyclone Formation Potential for Five-Day Period Ending 1100 AM PDT MON SEP 16 2013 Chance of Formation: Low < 30% Medium 30-50% High > 50% X indicates current disturbance location; shading indicates potential formation area.



Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <30% Medium 30-50% High >50%

TROPICAL WEATHER OUTLOOK NWS NATIONAL HURRICANE CENTER MIAMI FL 500 PM PDT WED SEP 11 2013

FOR THE EASTERN NORTH PACIFIC ... EAST OF 140 DEGREES WEST LONGITUDE ...

1. A BROAD AREA OF LOW PRESSURE LOCATED JUST SOUTH OF THE GULF OF TEHUANTEPEC IS PRODUCING A LARGE AREA OF DISORGANIZED SHOWERS AND THUNDERSTORMS. STRONG UPPER-LEVEL WINDS AND CLOSE PROXIMITY TO LAND ARE EXPECTED TO INHIBIT SIGNIFICANT DEVELOPMENT DURING THE NEXT FEW DAYS WHILE THIS DISTURBANCE DRIFTS NORTHWARD TOWARD THE COAST OF SOUTHERN MEXICO. THIS SYSTEM HAS A LOW CHANCE...10 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. **REGARDLESS OF DEVELOPMENT...THIS SYSTEM IN COMBINATION WITH ANOTHER DISTURBANCE EXPECTED TO BE IN THE BAY OF CAMPECHE...WILL BRING HEAVY RAINS TO PORTIONS OF EASTERN MEXICO FOR THE NEXT SEVERAL DAYS. THESE RAINS COULD CAUSE LIFE-THREATENING FLASH FLOODS AND MUD SLIDES.** 

FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2013. COMMENTS ON THE EXPERIMENTAL FORECASTS CAN BE PROVIDED AT...

HTTP://WWW.NWS.NOAA.GOV/SURVEY/NWS-SURVEY.PHP?CODE=ETWO

FORECASTER BROWN

### 00Z 8/12/2013 5-day genesis probability 20%



AN AREA OF LOW PRESSURE IS EXPECTED TO FORM ACROSS THE NORTHWESTERN CARIBBEAN SEA OR THE SOUTHERN GULF OF MEXICO BY THURSDAY OR FRIDAY...AND ENVIRONMENTAL CONDITIONS ARE FORECAST TO BECOME SOMEWHAT CONDUCIVE FOR DEVELOPMENT DURING THAT TIME. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

GFS 126-h forecast valid at 00Z 17 August 2013 850-mb relative vorticity and wind and MSLP

### 00Z 8/13/2013 5-day genesis probability 30%



CLOUDINESS AND SHOWERS EXTENDING FROM THE SOUTHWESTERN CARIBBEAN SEA NORTHEASTWARD ACROSS MOST OF THE CENTRAL CARIBBEAN TO NEAR HISPANIOLA ARE ASSOCIATED WITH A TROPICAL WAVE AND A BROAD AREA OF LOW PRESSURE INTERACTING WITH AN UPPER-LEVEL TROUGH. ENVIRONMENTAL CONDITIONS ARE FORECAST TO GRADUALLY BECOME MORE CONDUCIVE FOR DEVELOPMENT OVER THE NEXT SEVERAL DAYS AS THE LARGE DISTURBANCE MOVES TOWARD THE YUCATAN PENINSULA AND THE SOUTHERN GULF OF MEXICO. THIS SYSTEM HAS A LOW CHANCE...NEAR 10 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A MEDIUM CHANCE...30 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

GFS 102-h forecast valid at 00Z 17 August 2013 850-mb relative vorticity and wind and MSLP

### 00Z 8/14/2013 5-day genesis probability 40%



A TROPICAL WAVE OVER THE WESTERN CARIBBEAN SEA IS PRODUCING A LARGE AREA OF CLOUDINESS... SHOWERS...AND A FEW THUNDERSTORMS EXTENDING FROM CENTRAL AMERICA NORTHEASTWARD TO JAMAICA AND EASTERN CUBA. UPPER-LEVEL WINDS HAVE BECOME MORE FAVORABLE...AND SOME DEVELOPMENT OF THIS DISTURBANCE IS POSSIBLE OVER THE NEXT COUPLE OF DAYS AS IT MOVES NORTHWESTWARD AT 10 TO 15 MPH TOWARD THE YUCATAN PENINSULA AND SOUTHERN GULF OF MEXICO. ENVIRONMENTAL CONDITIONS COULD BE A LITTLE MORE MARGINAL FOR DEVELOPMENT WHILE THE SYSTEM IS OVER THE GULF OF MEXICO LATER THIS WEEK. THIS SYSTEM HAS A MEDIUM CHANCE... 30 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A MEDIUM CHANCE...40 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

GFS 84-h forecast valid at 06Z 17 August 2013 850-mb relative vorticity and wind and MSLP

### 00Z 8/15/2013 5-day genesis probability 80%



THE LOW PRESSURE SYSTEM IN THE NORTHWESTERN CARIBBEAN SEA IS MOVING TOWARD THE WEST-NORTHWEST AT 10 MPH...AND IS PRODUCING WIND GUSTS TO GALE FORCE IN SQUALLS TO THE EAST OF THE CENTER. ASSOCIATED SHOWER AND THUNDERSTORM ACTIVITY CONTINUES TO SHOW SIGNS OF ORGANIZATION...AND A TROPICAL DEPRESSION COULD FORM BEFORE THE DISTURBANCE REACHES THE YUCATAN PENINSULA ON THURSDAY. AFTER THAT...THE LOW IS FORECAST TO MOVE INTO THE SOUTHERN GULF OF MEXICO...WHERE UPPER-LEVEL WINDS COULD BECOME A LITTLE LESS FAVORABLE FOR DEVELOPMENT. THIS SYSTEM HAS A HIGH CHANCE...70 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A HIGH CHANCE...80 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. REGARDLESS OF WHETHER OR NOT A TROPICAL CYCLONE FORMS...HEAVY RAINS AND GUSTY WINDS ARE FORECAST TO SPREAD OVER THE YUCATAN PENINSULA...WESTERN CUBA...AND BELIZE DURING THE NEXT DAY OR TWO...AND INTERESTS IN THESE AREAS SHOULD MONITOR THE PROGRESS OF THIS DISTURBANCE.

GFS 78-h forecast valid at 00Z 18 August 2013 850-mb relative vorticity and wind and MSLP

### GOES-E IR Imagery and GFS Analysis valid 12Z 17 August 2013



### 00Z 8/28/13 5-day genesis probability 20%



A TROPICAL WAVE OVER WEST AFRICA IS EXPECTED TO MOVE OVER THE FAR EASTERN ATLANTIC IN ABOUT THREE DAYS. SOME DEVELOPMENT IS POSSIBLE AFTER THAT TIME WHILE THE SYSTEM MOVES WEST-NORTHWESTWARD AT 10 TO 15 MPH. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

GFS 126-h forecast valid at 00Z 2 September 2013 850-mb relative vorticity and wind and MSLP

# METEOSAT IR Imagery and GFS Analysis valid 00Z 2 September 2013



### Sandy – GFS Forecasts Valid 12Z 22 October 2012



At genesis Sandy had winds of 30 kt and a central pressure of 1002 mb
### Karen – GFS Forecasts Valid 06Z 3 October 2013



At genesis, Karen had winds of 45 kt and a central pressure of 1006 mb

Web site for monitoring real-time model forecasts of cyclogenesis:

http://www.emc.ncep.noaa.gov/gmb/tpm/emchurr/tcgen/

Web site of archived model forecasts of cyclogenesis for 2010: http://www.emc.ncep.noaa.gov/gmb/tpm/emchurr/ gfs\_gen\_2010/

An interesting case to look at: Tropical Storm Matthew, whose genesis was on 23 Sept 1200 UTC at 13.7°N 74.8°W

### CIRA – Tropical Cyclone Formation Probability Guidance Product

| Back Forward Www.ssd.noaa.gov/PS/TROP/TCFP/                           | atlantic.html  |                               | \$<br>\$<br>\$<br>\$          | C' X<br>Reload Stop Stop      | P Home Bookma   |
|---|--|-------------------------------|-------------------------------|-------------------------------|---|
| CIRA<br>Cooperative<br>Institute for<br>Research in the<br>Atmosphere | A Tropical Cyclone Formation Probability Guidance Product Developed by the Regional and Mesoscale Meteorology Branch at CIRA Cooperative Research Program   Office of Research and Applications/Center for Satellite Applications and Research |                               |                               |                               | RAMMB<br>Resional And<br>Mesoscale<br>Meteorology<br>Branch |
|   |  | Atlantic Basir                | ji                            |                               |   |
| TCFP Home<br>Product Description                                      | Products Last Updated 2013 MAR 15 06UTC  |                               |                               |                               |   |
| Basins <ul> <li>Atlantic</li> <li>East Pacific</li> </ul>             | 96-Hour Loop of<br>Real-time Formation<br>Probability  | Real-Time                     | Climatological                | Anomaly                       |   |
| • West Pacific<br>• Indian Ocean<br>Update Log<br>(internal use)      | Probability of TC<br>Formation within 24<br>Hours  | URR PROB (%) 2013 MAR15 062   | CLIM PROB (%) 2013 MAR15 062  |                               |   |
|   | 850 hPa Circulation (kt)<br>TC Formation Threshold<br>> -2.91kt  | CURR CIRC (kt) 2013 MAR15 062 | CLIM CRC (kt) 2013 MAR15 062  | ANOM CIRC (kt) 2013 MAR15 062 |   |
|   | Dorsont Bivals Colden  | URR PCCD (\$) 2013 MAR15 062  | CLIM PCCD (\$) 2013 MAR15 06Z | ANOM PECD (X) 2013 MAR15 062  |   |

http://www.ssd.noaa.gov/PS/TROP/TCFP/atlantic.html



**TIME SERIES OF TC GENESIS PARAMETERS -- 2012** 

### Model Genesis Page Now Includes Global Model Ensembles

### Sandy: forecasts from 2012102012 (24h prior to genesis) -- Hit



## Genesis Probability based on Model Output

- Verification conducted for CMC, ECMWF, GFS, NOGAPS, and UKMET genesis forecasts from 2004-2011. Full methodology and results available in Halperin et al. (2013), in revision.
- Real-time probabilities available for genesis forecasts from CMC, GFS, and NOGAPS at <u>moe.met.fsu.edu/modelgen</u>
- Shows the time and location of model forecast genesis (see right).
- Gives the probability of genesis occurring within 24 h and within 5 ° lat/lon of forecast genesis time and location.
- Additional experimental products planned to run in realtime during 2013 hurricane season.

 Example: GFS shows genesis near 15.5 ° N, 48 ° W on Aug 21 00Z. There is a 33% probability that genesis occurs between 10.5-20.5 ° N and 43-53 ° W between Aug 20 00Z and Aug 22 00Z, based on 246 historical GFS forecast cases.

Experimental Probability of TC Genesis GFS Model Output Initialized on 20120818 18Z





## Medium-Range Genesis Forecasts



 During the 2009-2012 hurricane seasons, NHC experimented with medium range genesis forecasts (0-5 and 3-5 day forecasts)





- " RETSHERE FIST & DERS TO S-RULT FUTUR SCHES. Y. KIL MODILS SISTE DU PROF OF THE SET OF HILL SET
- Verification results indicate superb forecast skill and a 5day genesis product is slated for release during the 2013 season

## Forecast Challenges 2012

#### Classification









Guidance disagreement



# Forecast Challenges 2013

#### Genesis on the coast

Rapid intensification near the coast









Communications





ZCZC MIATCDAT5 ALL TTAA00 KNHC DDHHMM

TROPICAL STORM ERNESTO DISCUSSION NUMBER 12 NWS NATIONAL HURRICANE CENTER MIAMI FL AL052012 1100 AM AST SAT AUG 04 2012

DESPITE THE EXCELLENT PRESENTATION ON SATELLITE WITH CYCLONICALLY CURVED CONVECTIVE BANDS AND A WELL ESTABLISHED UPPER-LEVEL OUTFLOW...DATA FROM A RECONNAISSANCE PLANE INDICATE THAT ERNESTO HAS NOT BECOME ANY BETTER ORGANIZED. IN FACT...THE WINDS HAVE DECREASED TO 45 KT AND THE PRESSURE HAS RISEN TO 1008 MB. I DO NOT HAVE ANY REASONS FOR THE CURRENT WEAKENING BUT I HAVE NO REASON TO FORECAST ADDITIONAL WEAKENING EITHER. THE SHEAR IS ANTICIPATED TO REMAIN LOW ACROSS THE CARIBBEAN...AND ERNESTO WILL MOVE OVER AN OCEAN WITH HIGHER HEAT CONTENT. GIVEN SUCH CONDITIONS...THE OFFICIAL FORECAST CALLS FOR ERNESTO TO BECOME A HURRICANE IN THE WESTERN CARIBBEAN. THIS FORECAST IS UNCERTAIN SINCE MODELS ARE IN DISAGREEMENT. SHIPS...LGEM AND THE GFDL FORECAST ERNESTO TO BECOME A HURRICANE WHILE THE HWRF EITHER FORECASTS NO CHANGE OR WEAKENING. Thanks to AF Hurricane Hunter Plane



#### FORECAST POSITIONS AND MAX WINDS

 INIT
 04/1500Z
 14.4N
 68.7W
 45 KT
 50 MPH

 12H
 05/0000Z
 14.8N
 71.2W
 45 KT
 50 MPH

 24H
 05/1200Z
 15.5N
 74.5W
 50 KT
 60 MPH

 36H
 06/0000Z
 15.7N
 77.5W
 65 KT
 75 MPH

 48H
 06/1200Z
 16.5N
 80.5W
 70 KT
 80 MPH

 72H
 07/1200Z
 18.0N
 84.0W
 80 KT
 90 MPH

 96H
 08/1200Z
 19.5N
 87.0W
 70 KT
 80 MPH

 120H
 09/1200Z
 22.0N
 90.5W
 60 KT
 70 MPH

\$\$ FORECASTER AVILA

#### b) 1145 UTC 4 August







#### Structure





Karen







Forecast Valid: 06Z200CT2013

Storm Center: 14.3N 258.9W

> Intensity: 32kts

