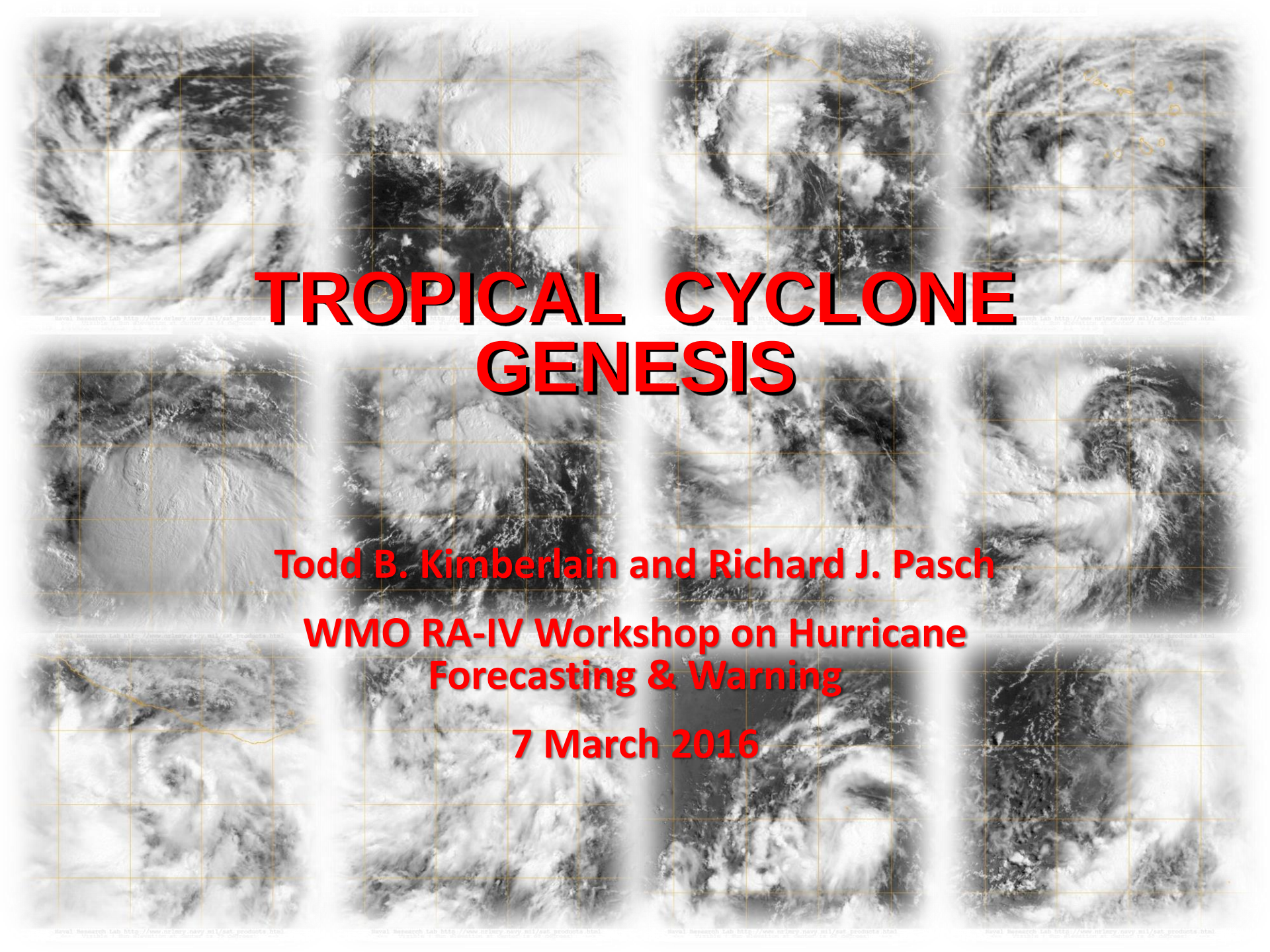


TROPICAL CYCLONE GENESIS

Todd B. Kimberlain and Richard J. Pasch

WMO RA-IV Workshop on Hurricane Forecasting & Warning

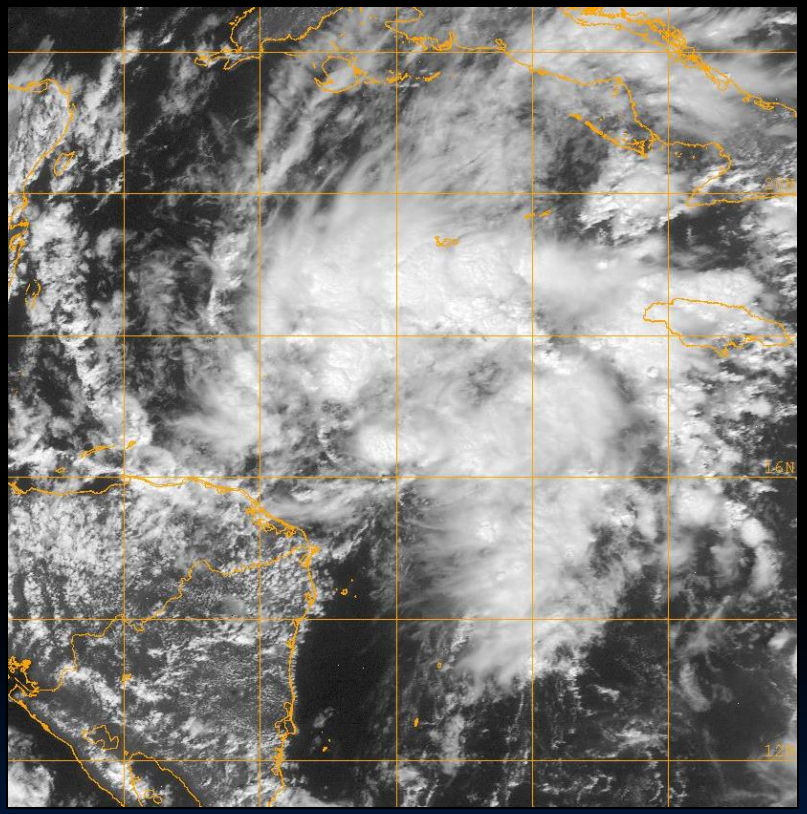
7 March 2016

Outline / Topics

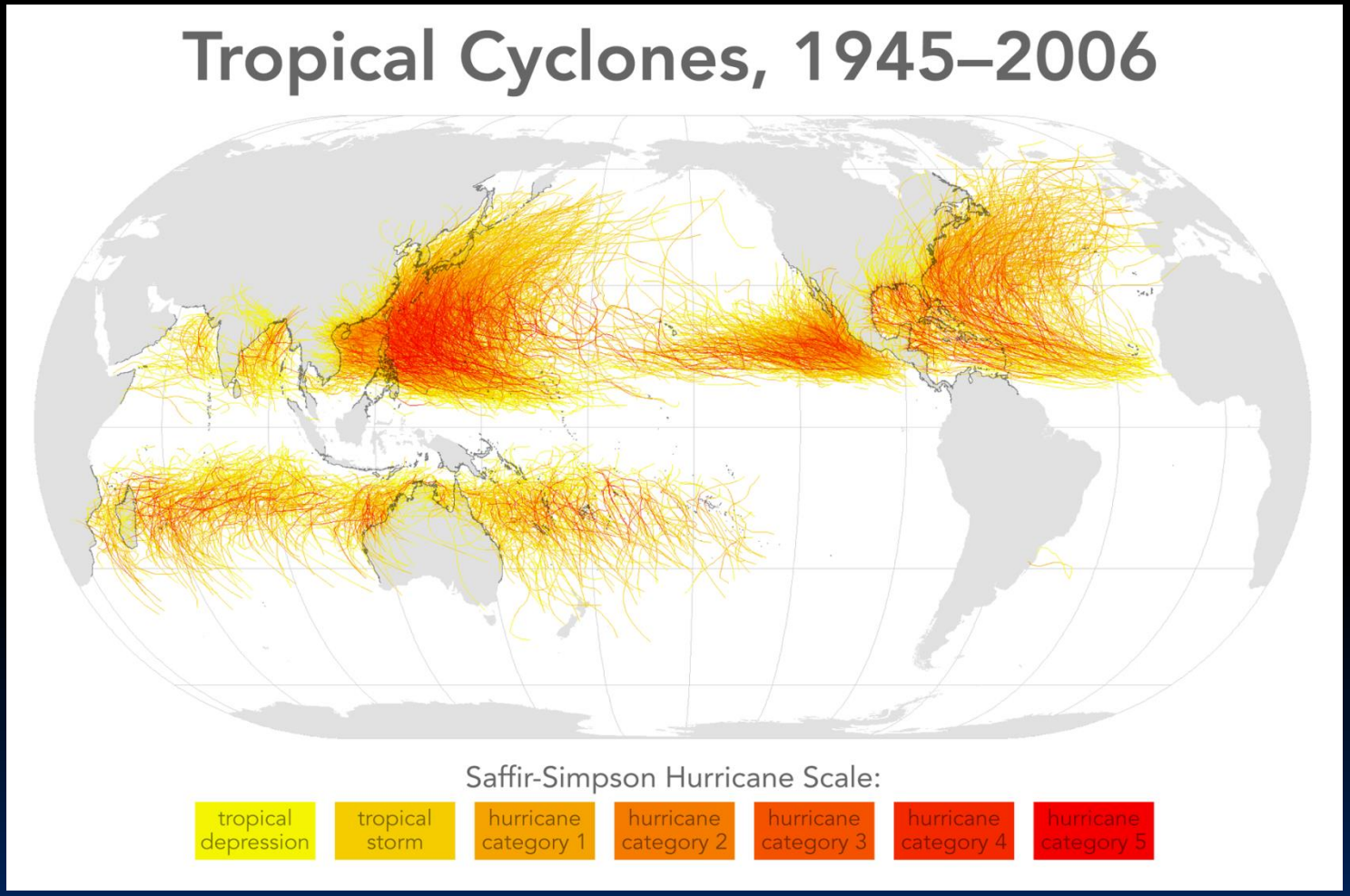
- Climatology
- Large-scale conditions associated with tropical cyclone (TC) formation
- Relation to ENSO, intraseasonal variability
- Theories of genesis
- Meso-scale aspects of genesis
- TC genesis in global models
- Web sites of genesis parameters
- Operational (NHC) genesis forecasting
- Forecast exercise

WMO Definition of a Tropical Cyclone:

"A warm-core, non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection and closed surface wind circulation about a well-defined center."



Principal Areas of Tropical Cyclone Formation



Factors Governing the Climatology of Tropical Cyclone Formation in the Atlantic Basin

- In the long-term mean, typically, there is a lag between the occurrence of the most favorable thermodynamic conditions (in terms of static stability) and the most favorable dynamical conditions (in terms of vertical wind shear).
- The atmosphere tends to be more unstable later in the season.
- The vertical shear tends to be weaker earlier in the season.

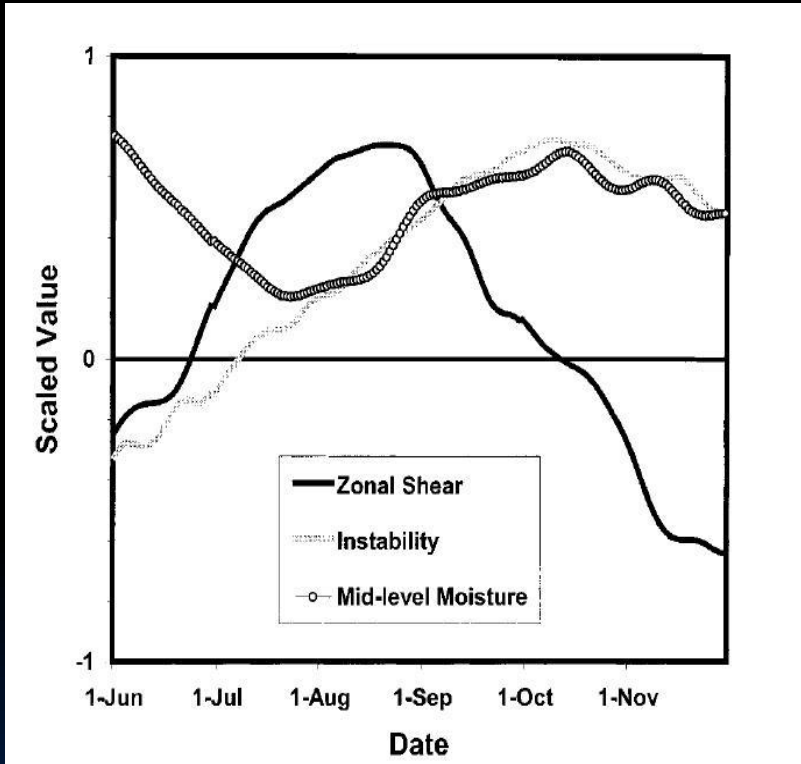
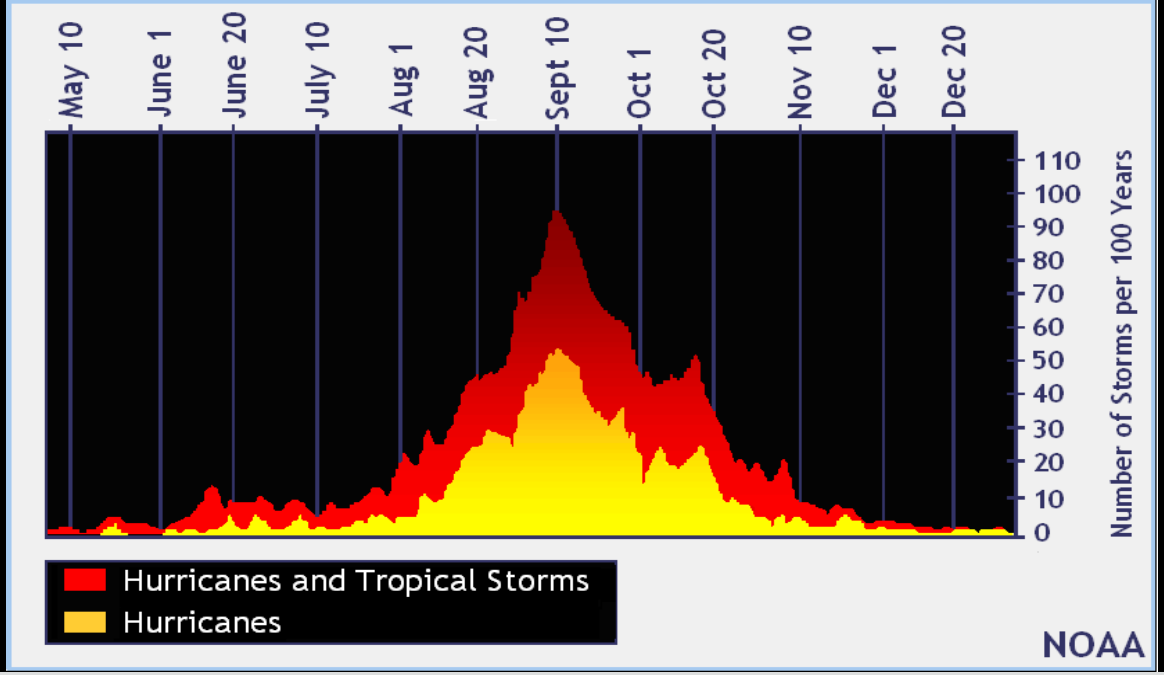
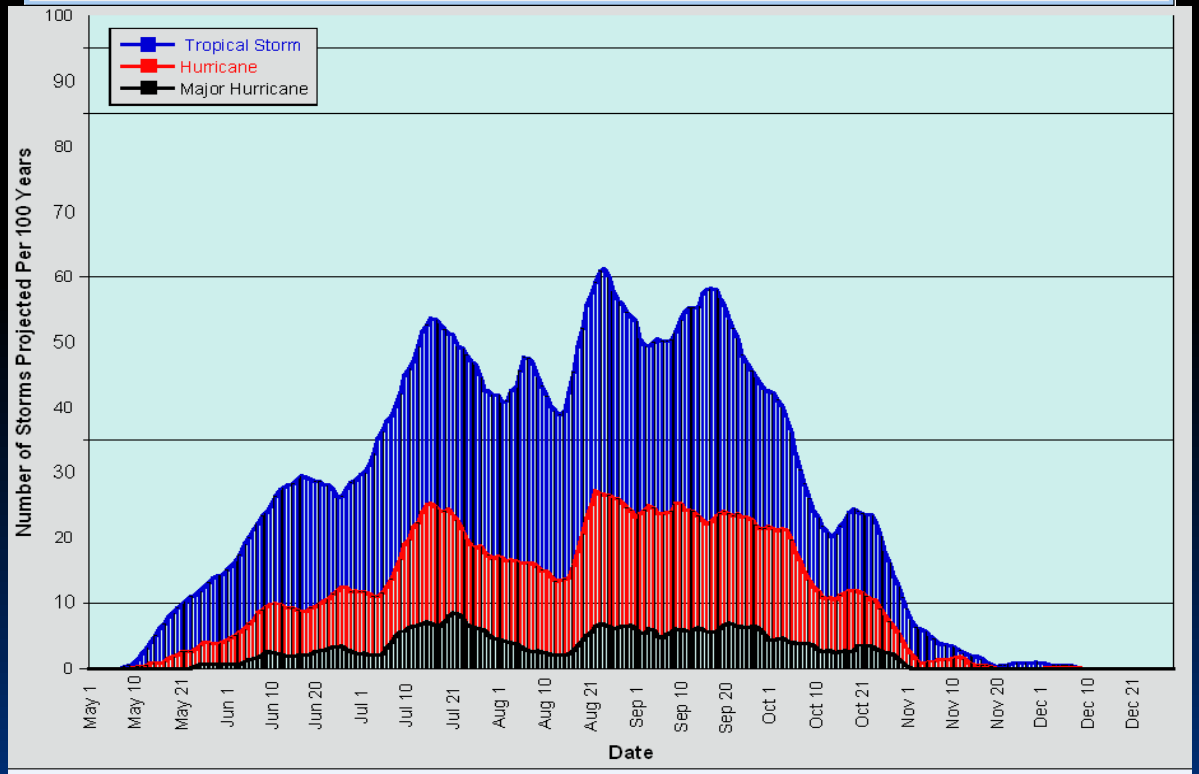


FIG. 7. Climatological time series of the scaled shear, instability, and moisture variables.



Atlantic

Highly peaked with a secondary peak in mid-October

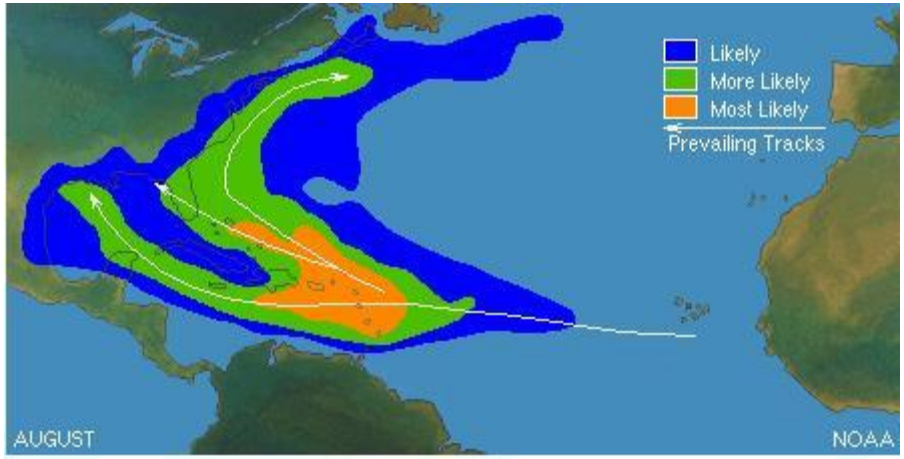


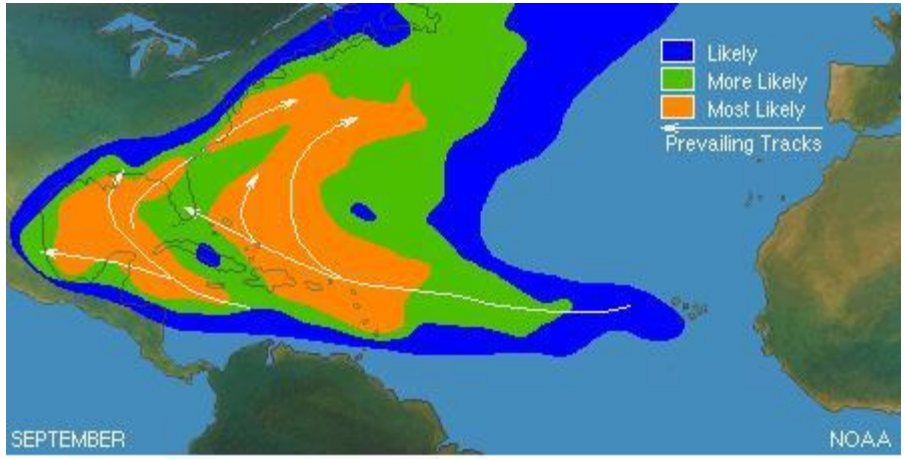
Eastern North Pacific

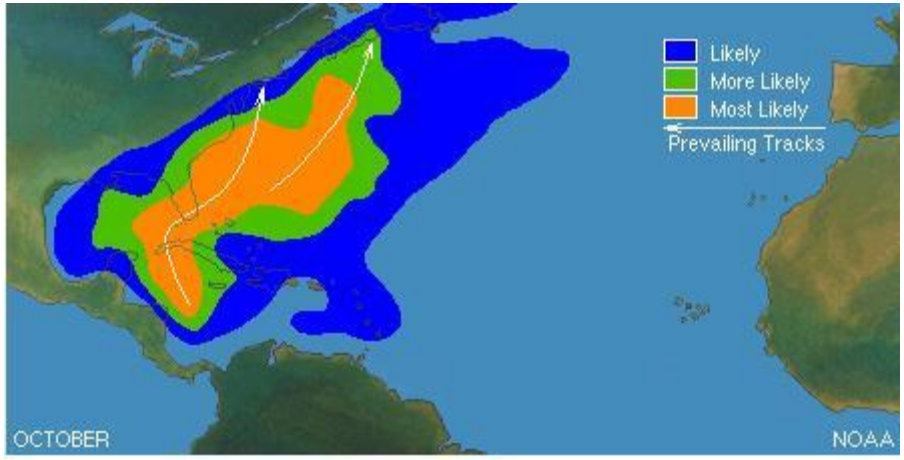
Bimodal distribution

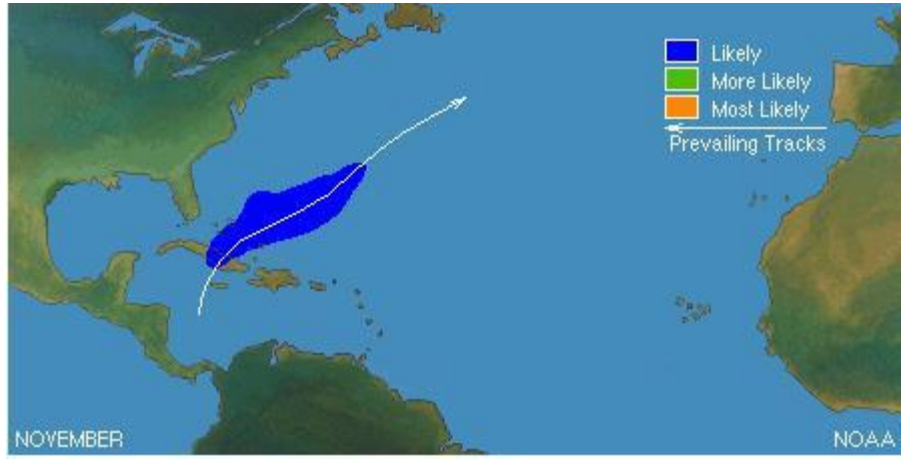

Likely
More Likely
Most Likely
Prevailing Tracks
JUNE
NOAA


Likely
More Likely
Most Likely
Prevailing Tracks
JULY
NOAA

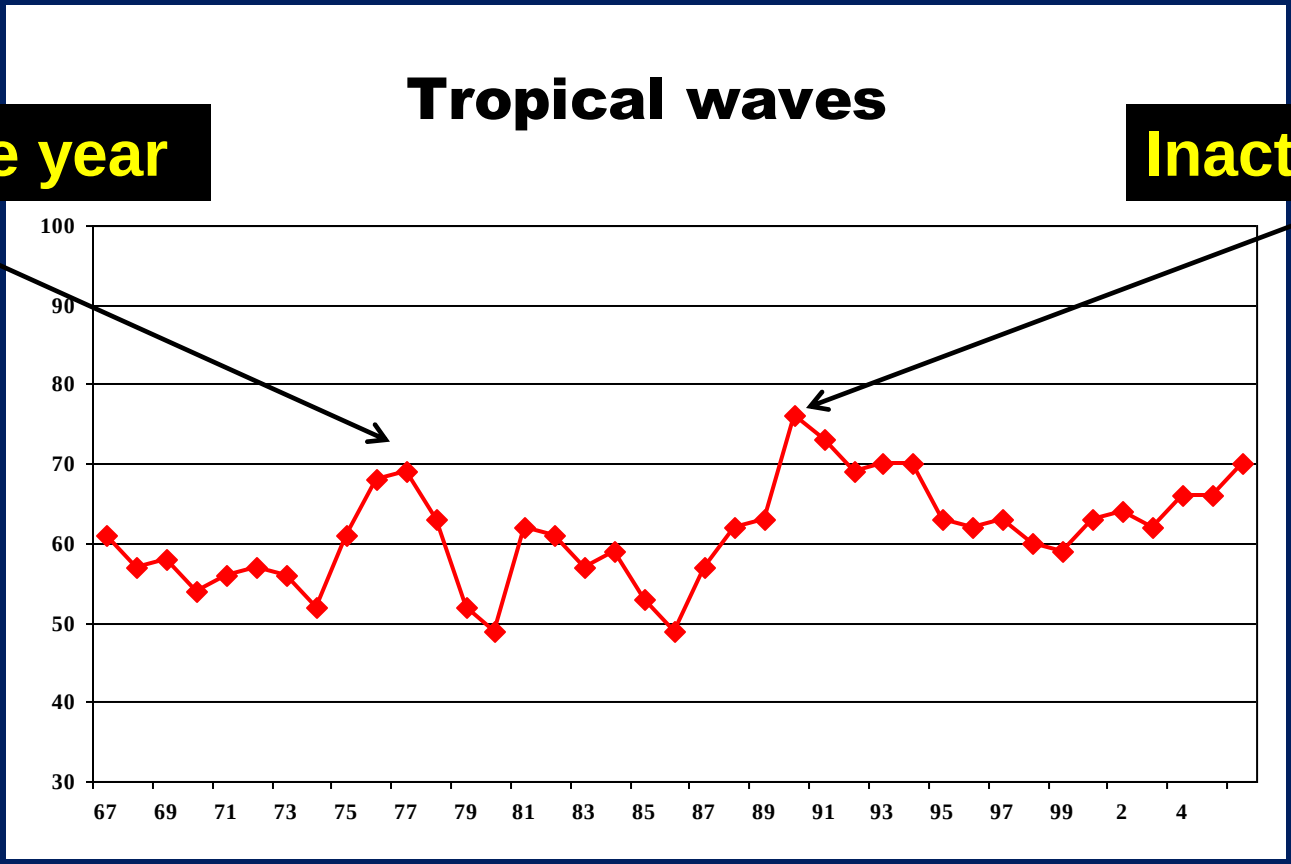

Likely
More Likely
Most Likely
Prevailing Tracks
AUGUST
NOAA


Likely
More Likely
Most Likely
Prevailing Tracks
SEPTEMBER
NOAA


Likely
More Likely
Most Likely
Prevailing Tracks
OCTOBER
NOAA


Likely
More Likely
Most Likely
Prevailing Tracks
NOVEMBER
NOAA

Interannual variability of the frequency of Atlantic tropical waves, 1967-2005

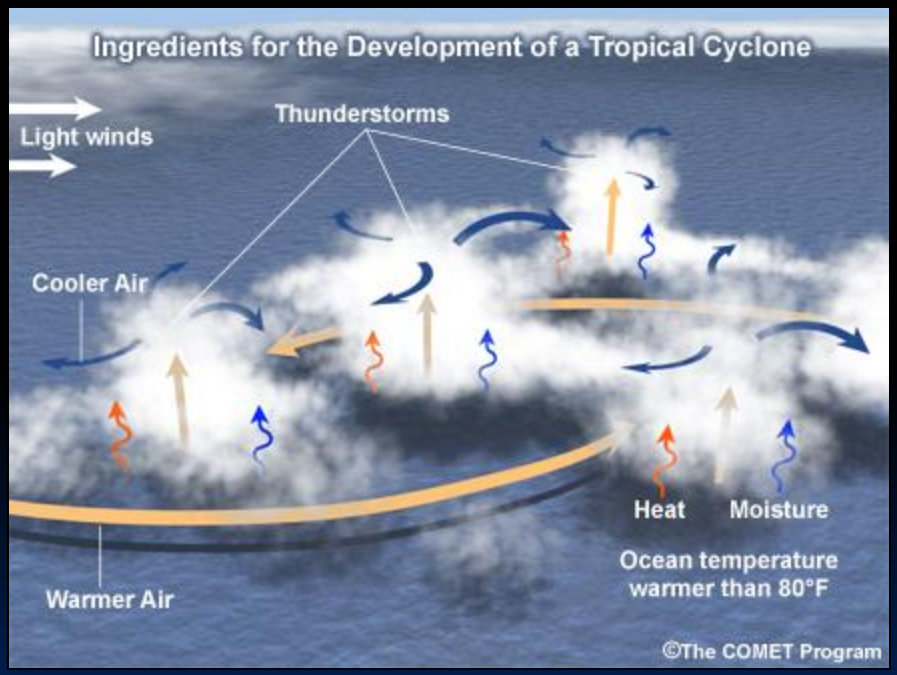


Note that TC genesis is *not* a function of the number of available disturbances.

Large-Scale Conditions and Other Characteristics Associated with TC Formation

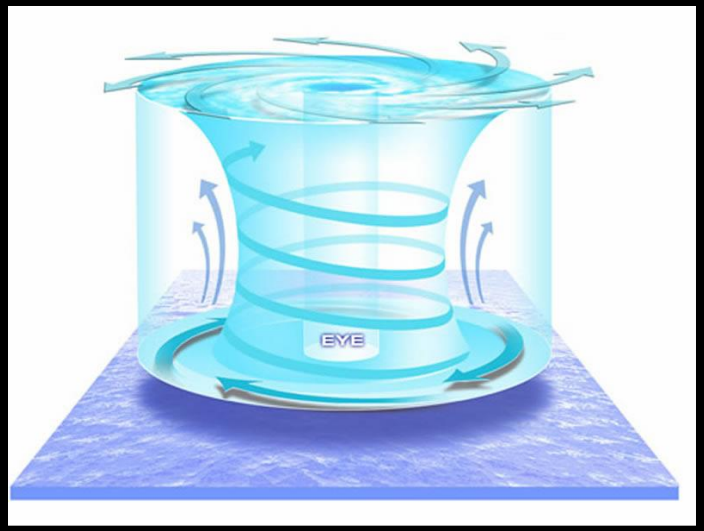
Necessary but not sufficient conditions!

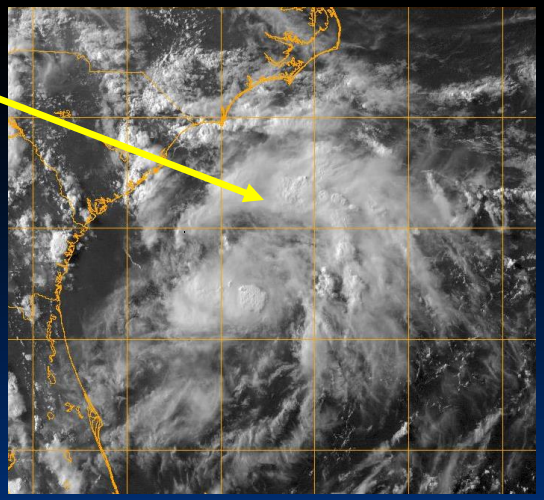
- A pre-existing disturbance containing abundant deep convection
- Latitudes poleward ~5º
- Adequate ocean thermal energy
  - SST > 26ºC extending to a depth of 60 m
- A "sufficiently" unstable atmosphere & deep layer of moist air
- Small vertical shear of the horizontal wind



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



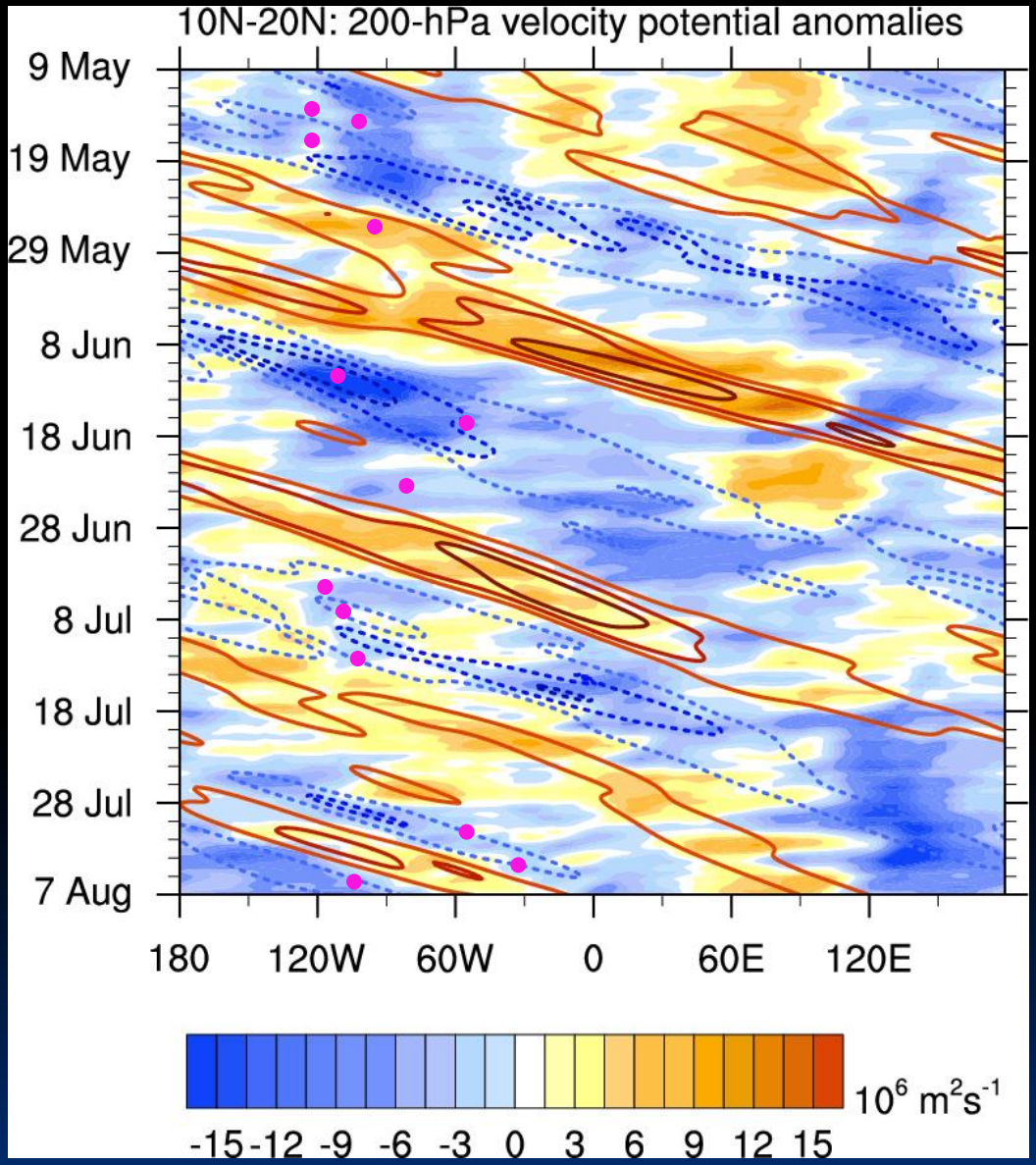


"We observe universally that tropical storms form only within pre-existing disturbances…An initial disturbance therefore forms part of the starting mechanism. A weak circulation, low pressure and a deep moist layer are present at the beginning. The forecaster need not look into areas which contain no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

Herbert Riehl (1954)

Important Intraseasonal Predictors for 5-Day Genesis Forecasts

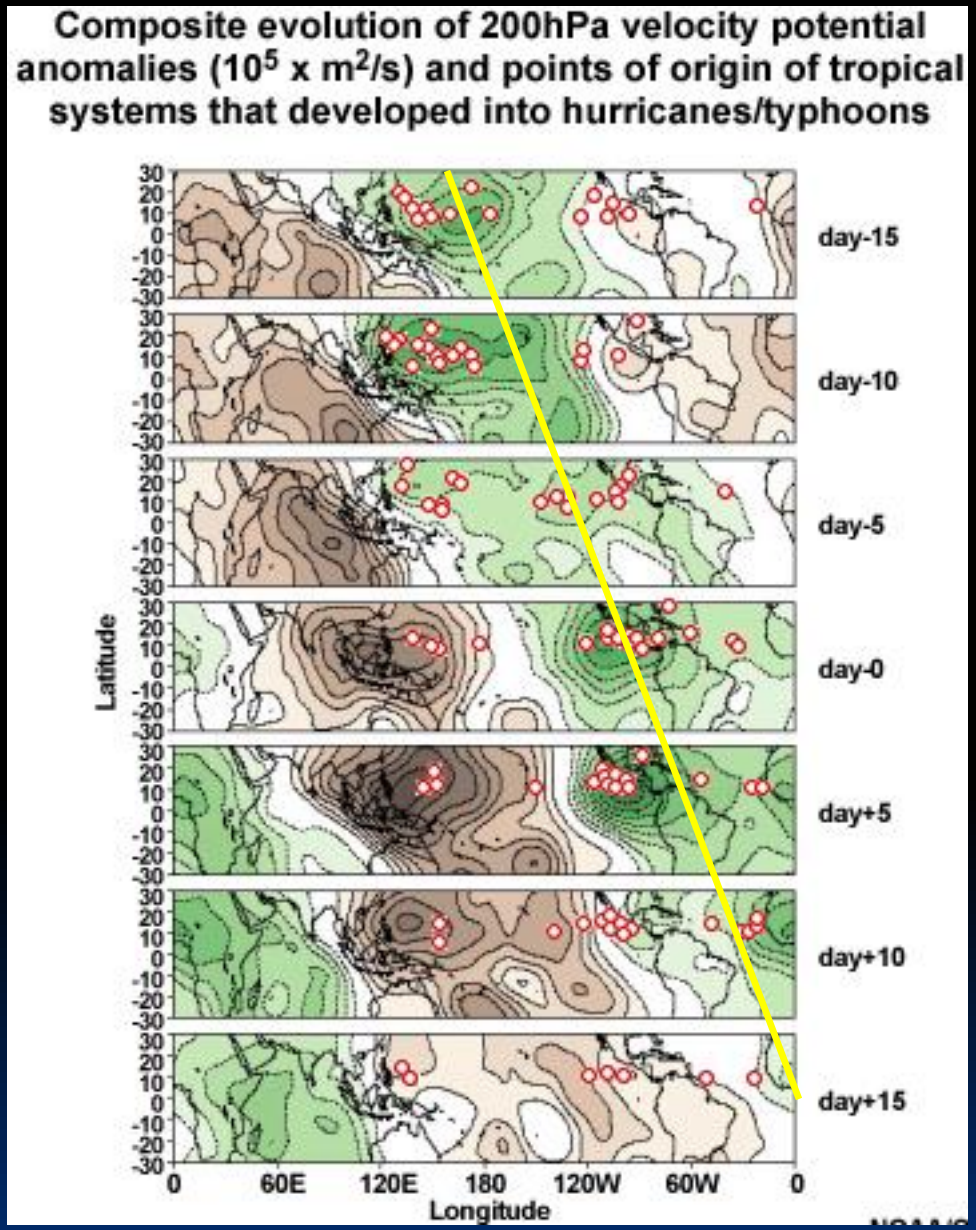
Blue–favorable upper-level conditions (lower shear and more unstable)

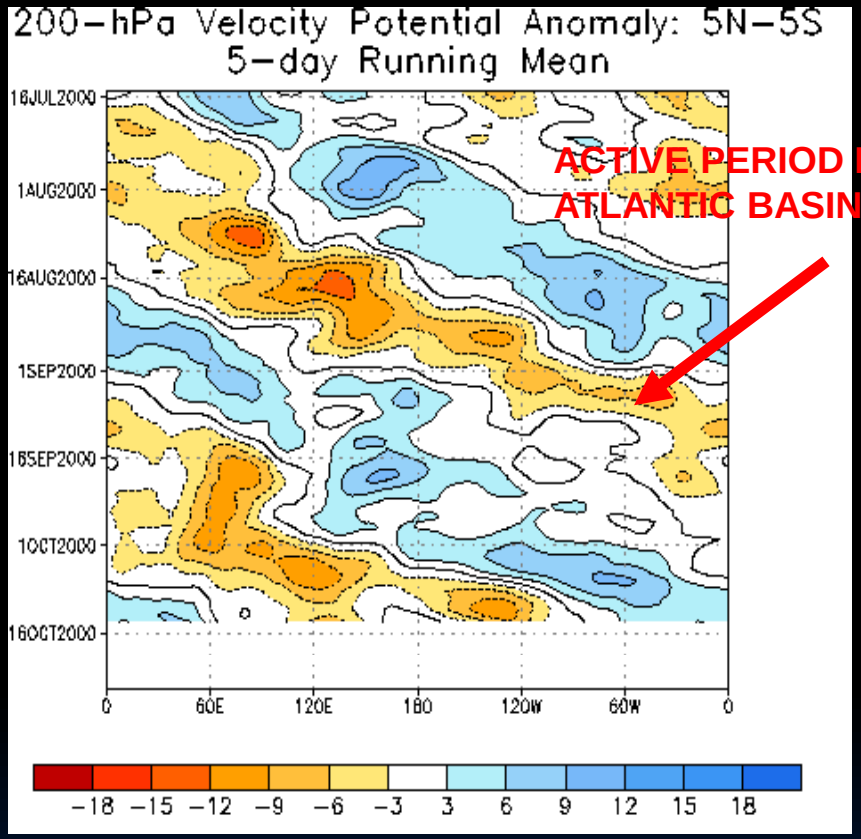


Magenta dots are TC genesis points in early 2012

Diagnostic tools involving the MJO and other intraseasonal oscillations are becoming increasingly important but are still used qualitatively

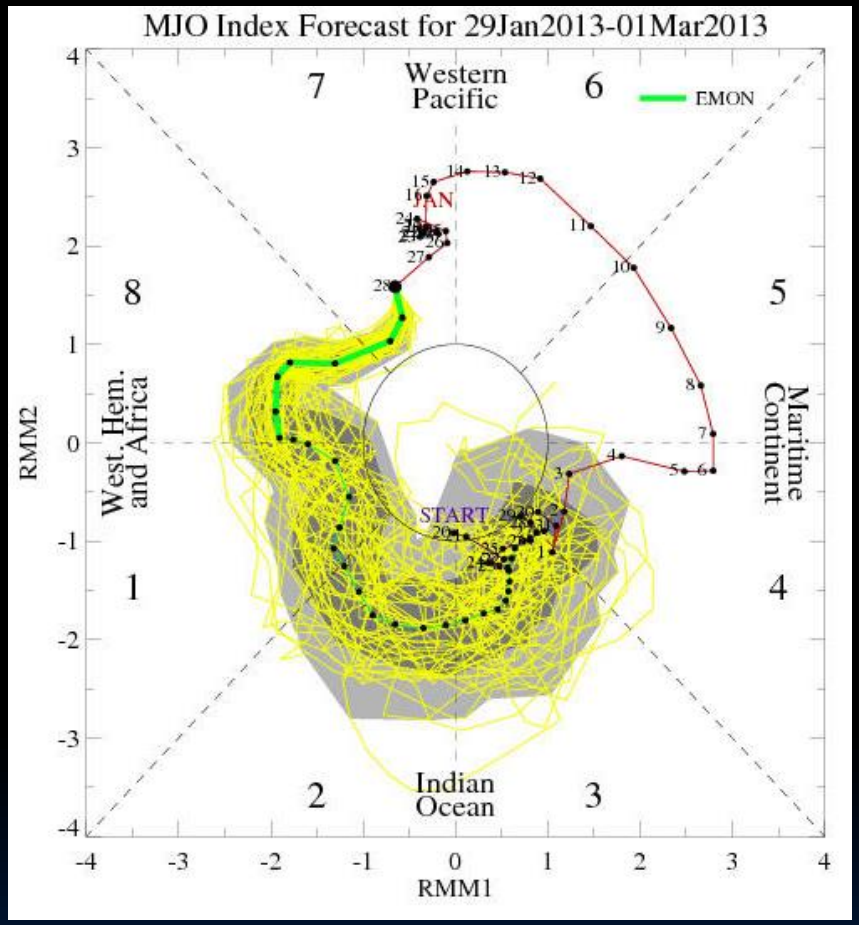
MADDEN-JULIAN OSCILLATION: RELATED TO INTRASEASONAL VARIABILITY IN TC ACTIVITY?

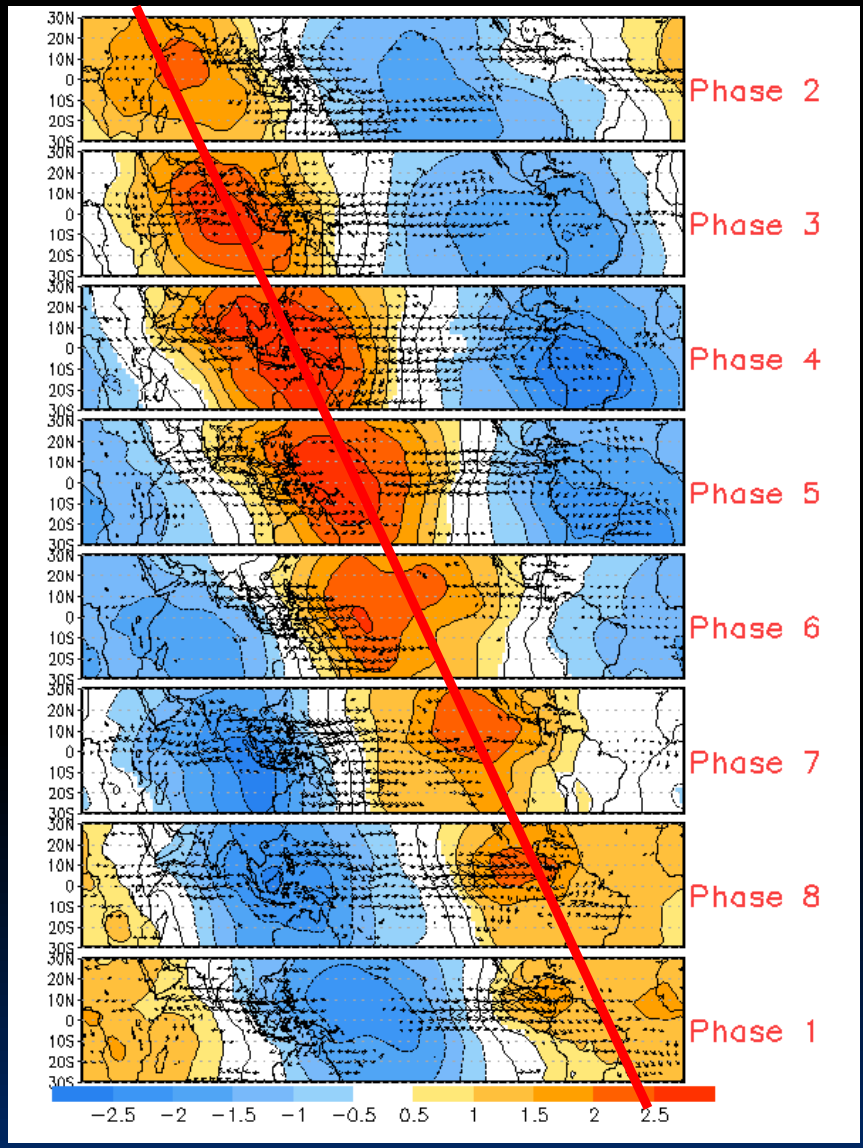




200 MB VELOCITY POTENTIAL 5°N-5°S 5-DAY RUNNING MEAN

A Tool for Tracking and Forecasting the MJO

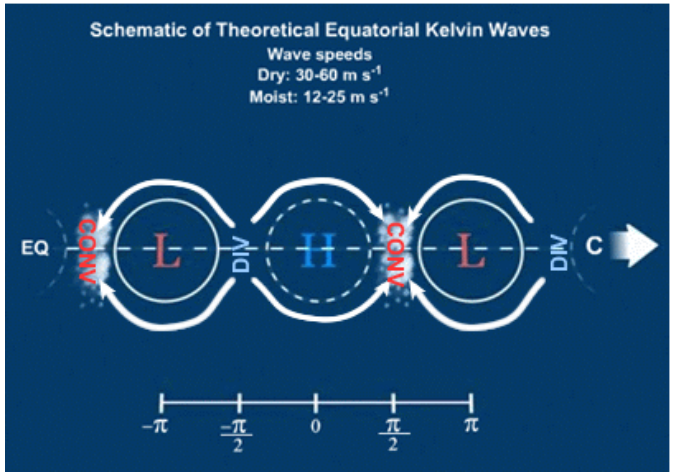




- Conceptual model showing idealized phases of MJO progression
- Phases 8 through 3 most active phases for the Atlantic

Idealized CCKW-influenced TC genesis

Day -2



Region of enhanced cyclonic vorticity generation

Background easterly flow

Disturbance

EQ

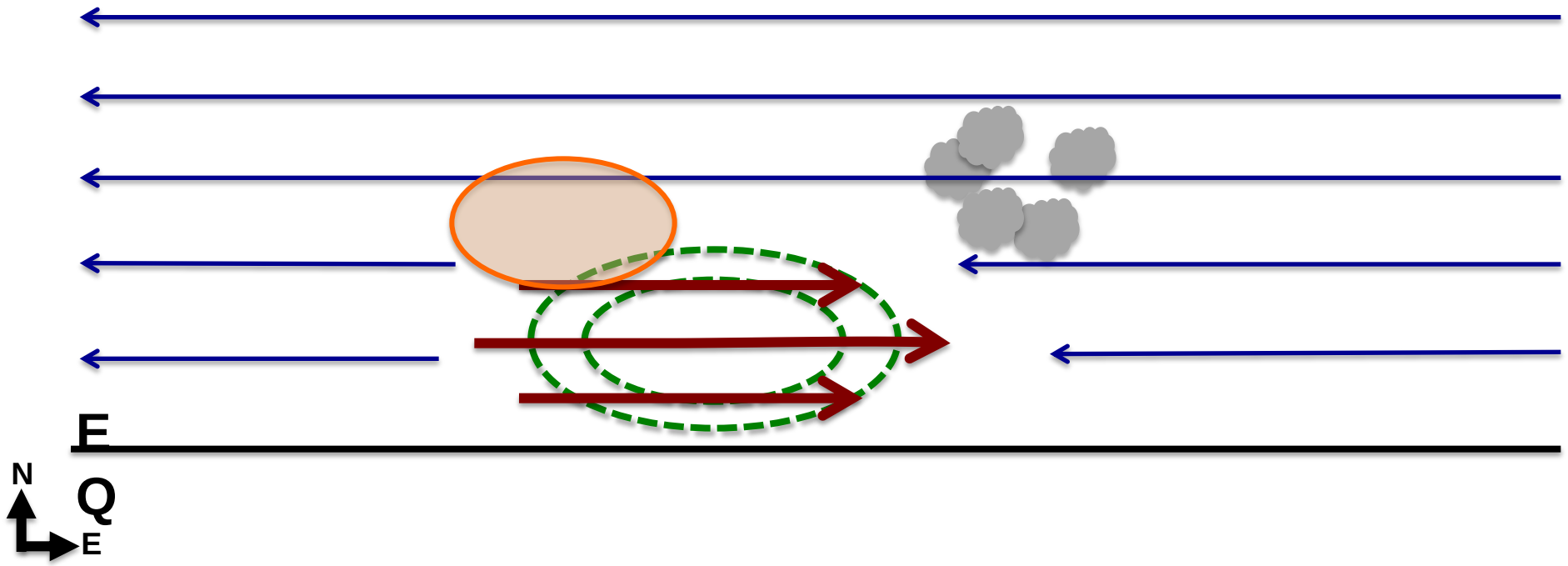
Eastward propagating CCKW, indicated by negative OLR anomalies and low-level anomalous westerly winds

N

E

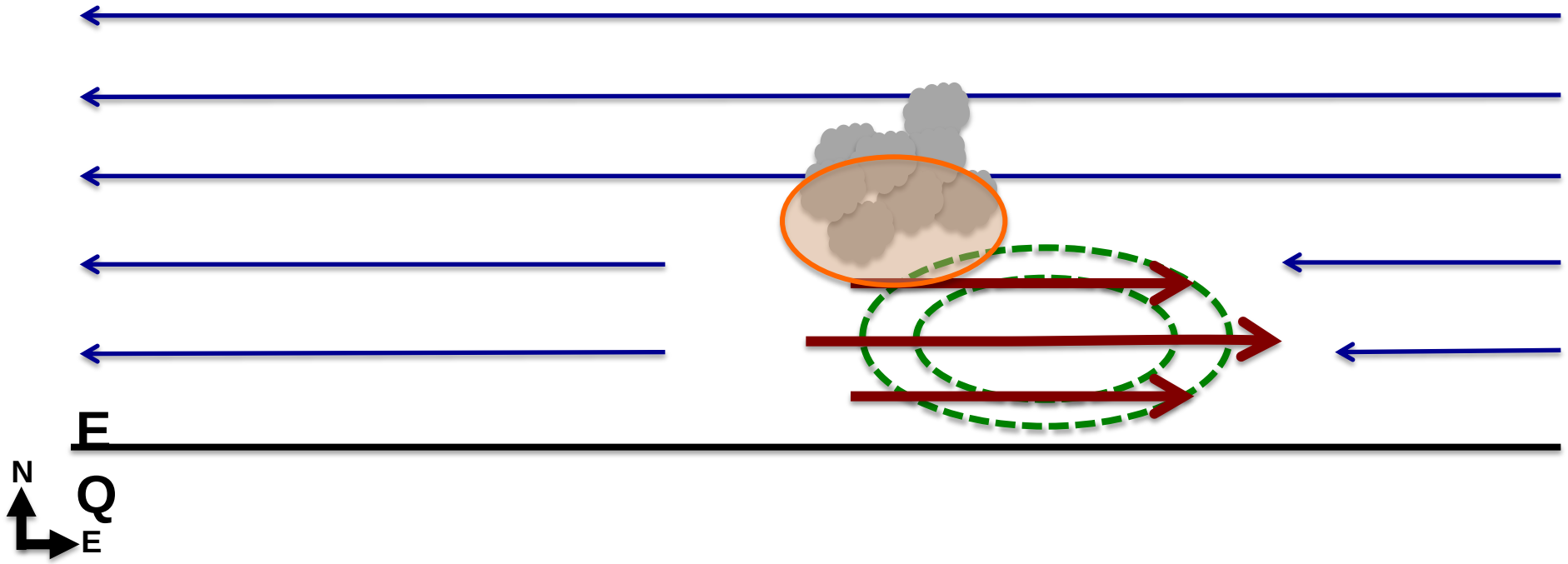
Idealized CCKW-influenced TC genesis

Day -1



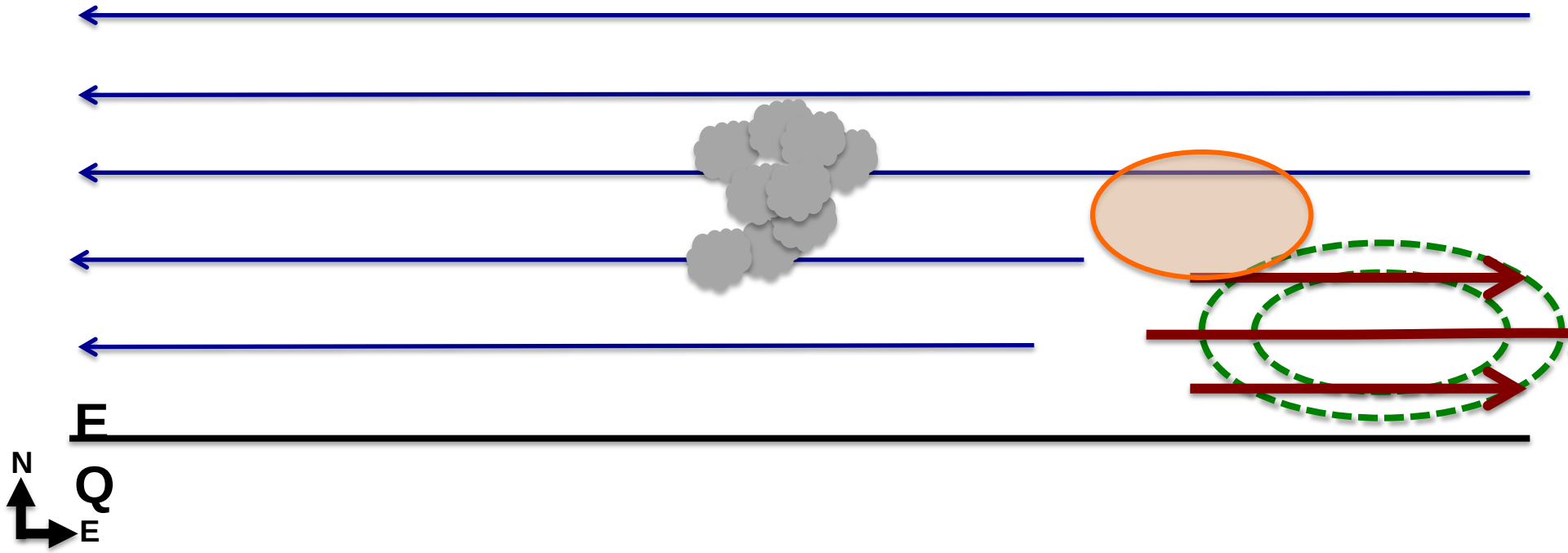
Idealized CCKW-influenced TC genesis

Day 0



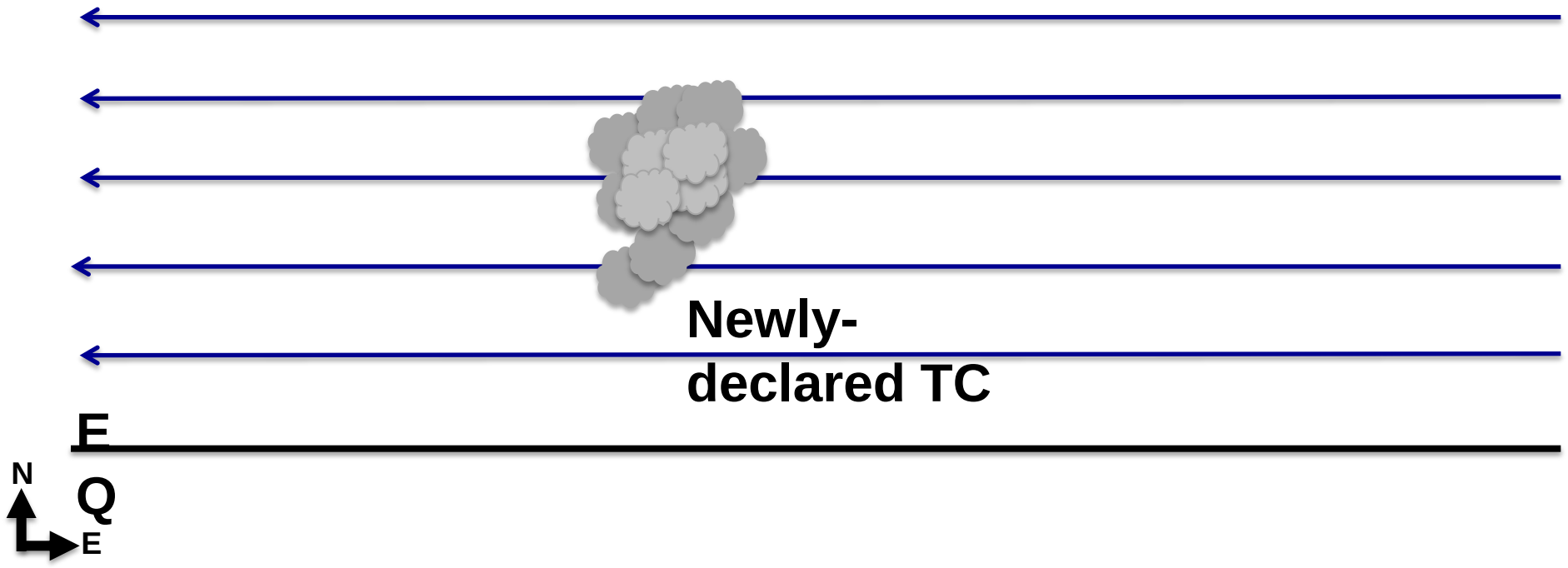
Idealized CCKW-influenced TC genesis

Day +1



Idealized CCKW-influenced TC genesis

Day +2



How are Intraseasonal Oscillations Used at NHC?

- Used as a way to increase forecaster confidence in a given situation if conceptual model of CCKWs and genesis matches model solutions.

- Any adjustments to 5-day genesis probabilities based on intraseasonal signals are small and subjectively determined.

- Global models handle the MJO much more accurately than individual CCKWs, and thus the forecaster can add value to the deterministic models.

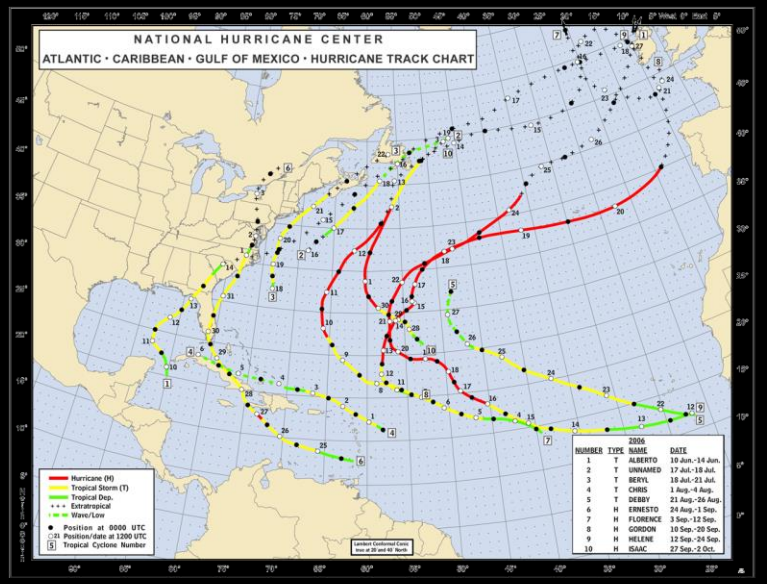
- No operational standard on use of CCKW in genesis forecasts (about half of forecasters use it).

Influence of El Niño/La Niña on TC Genesis

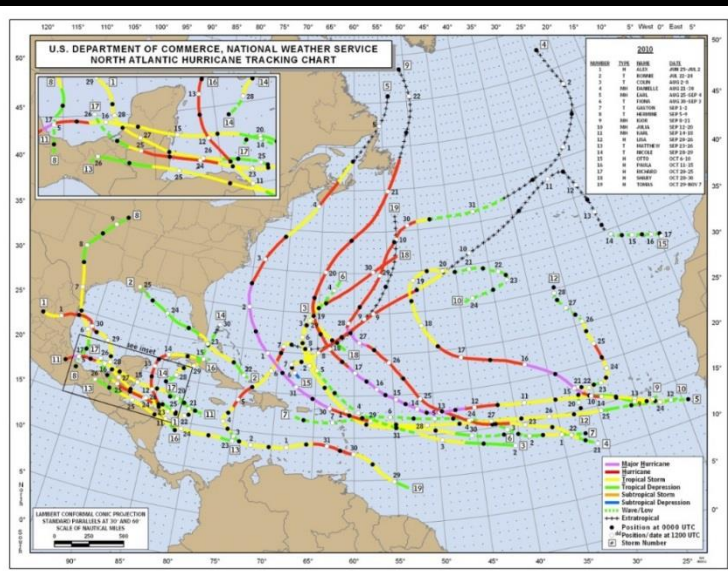
• During El Niño episodes, *fewer* TCs form over the deep tropical Atlantic and Caribbean; tendency for more to form at subtropical latitudes. The opposite generally occurs during La Niña years.

• In the eastern North Pacific, El Niño typically *enhances* TC activity, with a tendency for stronger hurricanes during El Niño (e.g., 1997, 2006).

2006 (El Niño)



2010 (La Niña)



2 Formal Theories of TC Genesis

- CISK (Ooyama, Charney and Eliasen)
- WISHE (Emanuel)

CISK

Acronym for:

Conditional **I**nstability of the **S**econd **K**ind

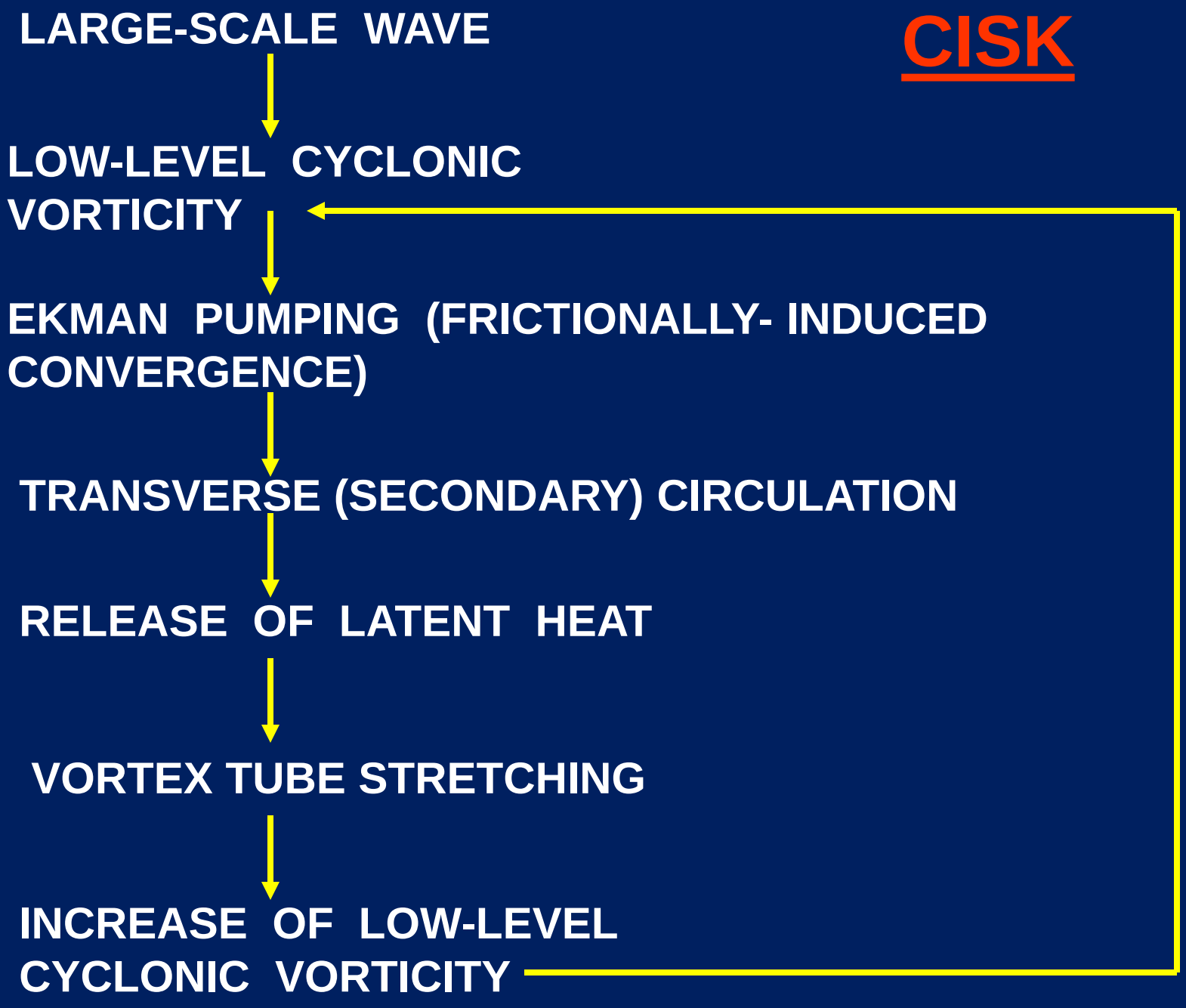
- A cooperative feedback between small-scale convection (frictionally-induced convergence and latent heat release) and the larger-scale circulation (a growing disturbance)

- A simplified linear theory which assumes that flow is in gradient balance

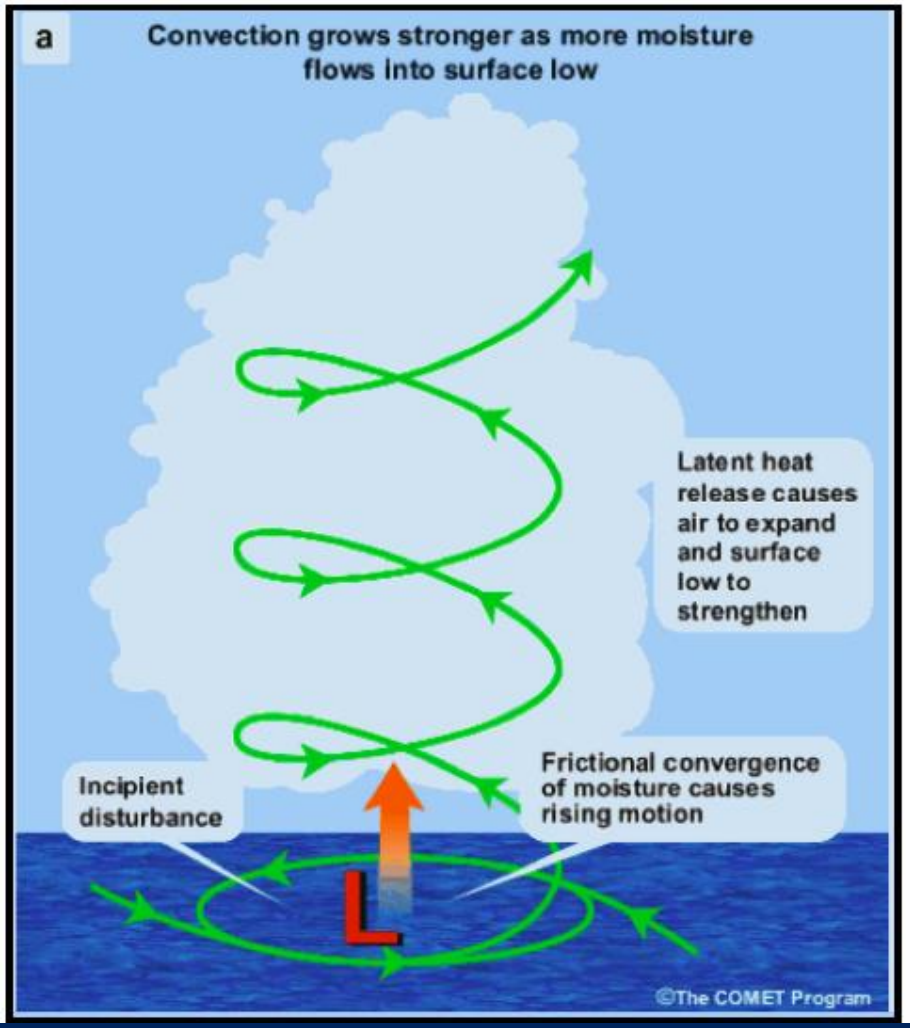
- When latent heat release balances surface frictional dissipation, the cyclone maintains its intensity

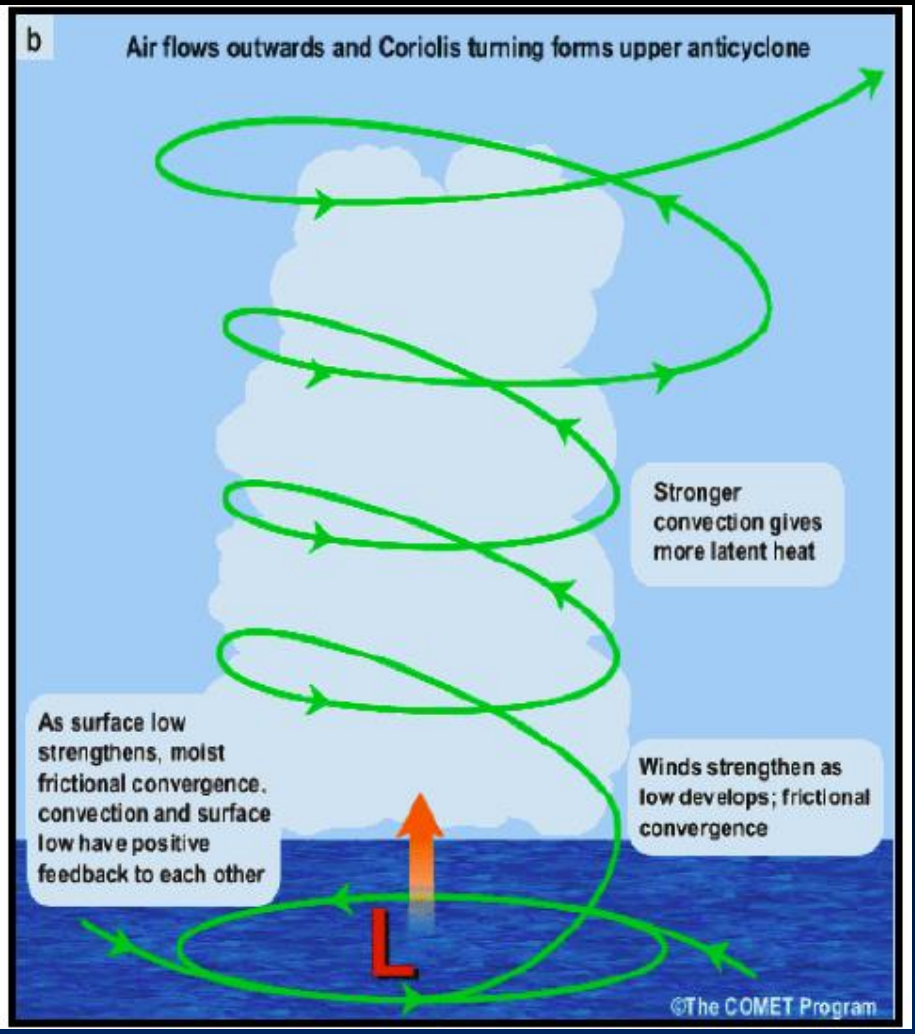
NOTE: ALTHOUGH THIS THEORY IS FREQUENTLY ATTACKED, IT STILL HAS SOME INTUITIVELY APPEALING ASPECTS!

CISK


LARGE-SCALE WAVE
LOW-LEVEL CYCLONIC VORTICITY
EKMAN PUMPING (FRICTIONALLY- INDUCED CONVERGENCE)
TRANSVERSE (SECONDARY) CIRCULATION
RELEASE OF LATENT HEAT
VORTEX TUBE STRETCHING
INCREASE OF LOW-LEVEL CYCLONIC VORTICITY

CISK Schematic





“The more fundamental question about the CISK concept is how can cooperation between cyclone-scale and convective-scale circulations produce their simultaneous development including the formation and intensification of a warm core? It is difficult to see how it can happen because, if there are no sources, θ_e is simply redistributed by these motions individually, and therefore by the total motion, without creating a new maximum. Conditional instability simply converts the vertical variation of θ_e to the horizontal variation while the mass distribution in θ_e space is conserved. Any instability that changes this distribution, therefore, inevitably involves processes other than cooperation between cyclone-scale circulation and convective clouds. Since the cooperation alone does not produce new instability, the concept of CISK as distinguished from the usual conditional instability can hardly be justified.”

(Arakawa, 2004 *J. Climate*)

This suggests that another mechanism for TC genesis, that involves thermodynamics and a source of heat, should be invoked.

WISHE is such a mechanism.

WISHE

Wind **I**nduced **S**urface **H**eat **E**xchange

-Heat release and instability in the free troposphere is governed by the evaporation of moisture from the sea (i.e., the extraction of energy from the underlying ocean surface)

-Evaporation is primarily determined by the magnitude of the surface winds

WISHE

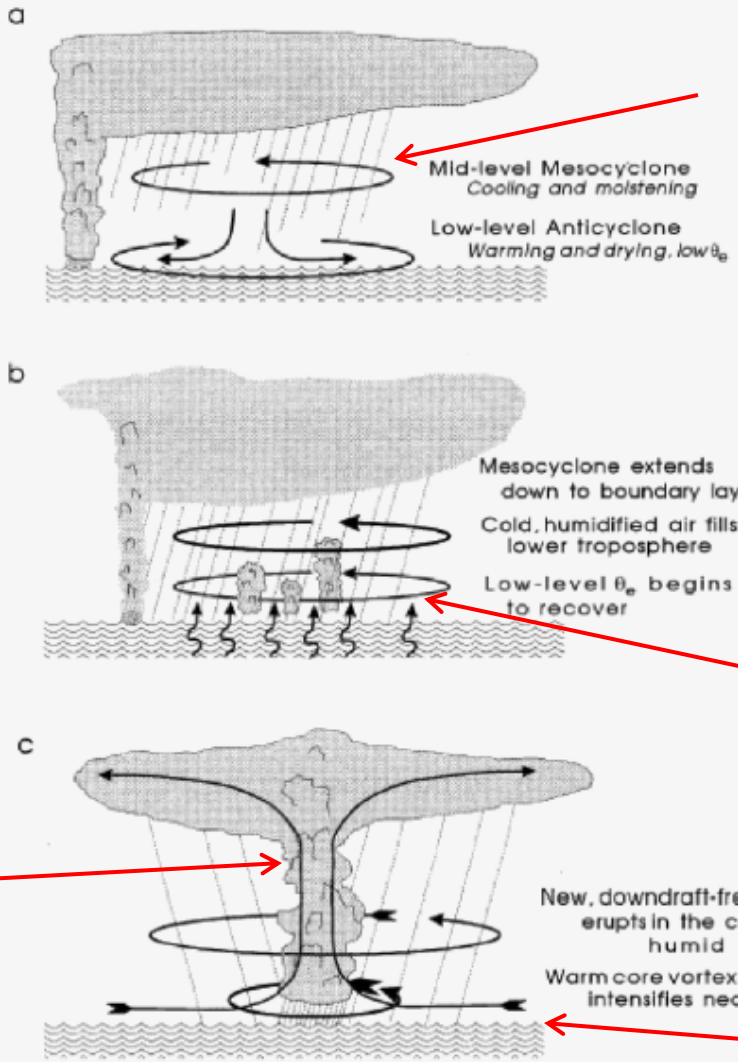


Figure 8. Conceptual model of tropical cyclogenesis from a preexisting MCS. (a) Evaporation of stratiform precipitation cools and moistens the upper part of the lower troposphere; forced subsidence leads to warming and drying of the lower part. (b) After several hours there is a cold and relatively moist anomaly in the whole lower troposphere. (c) After some recovery of the boundary layer θ_e convection redevelops (From Bister and Emanuel 1997, Copyright American Meteorological Society).

DEEP CONVECTION, INITIATED THROUGH EKMAN PUMPING, WILL PRODUCE CONVECTIVE-SCALE DOWNDRAFTS THAT WILL STABILIZE THE LOWER LAYER OF THE ATMOSPHERE

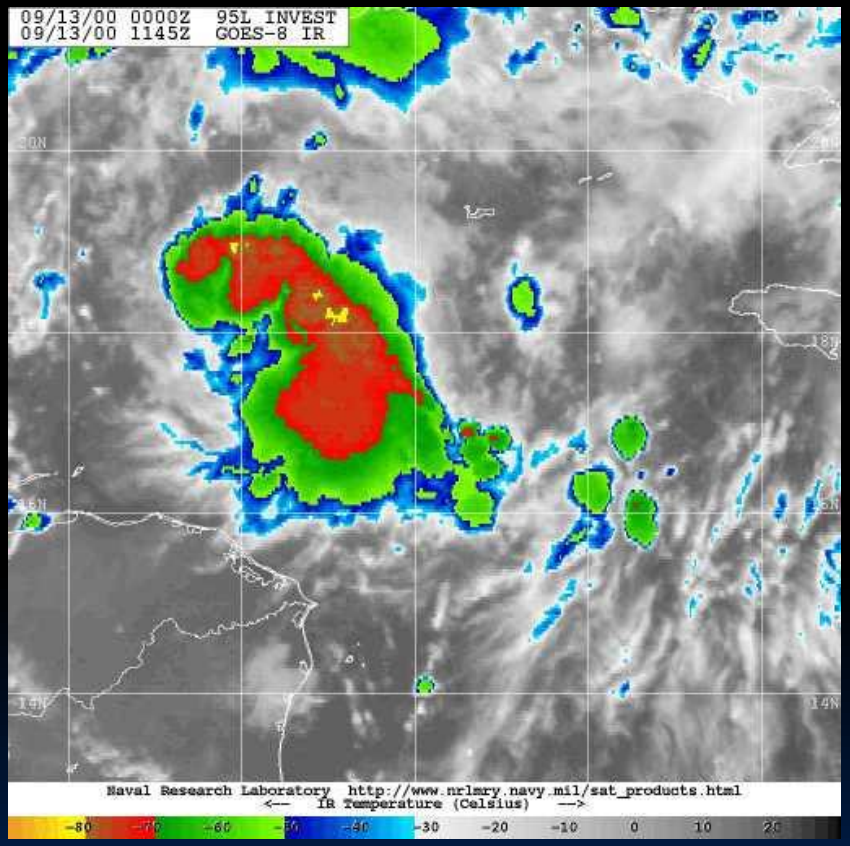
THE TROPOSPHERE MUST BECOME NEARLY SATURATED IN THE VORTEX CORE

CONVECTION CAN INCREASE THE TEMPERATURE OF THE VORTEX CORE. IN A MOIST TROPICAL ATMOSPHERE, THE WISHE PROCESS CAN ACT AS A POSITIVE FEEDBACK TO THE WARM-CORE CYCLONE.

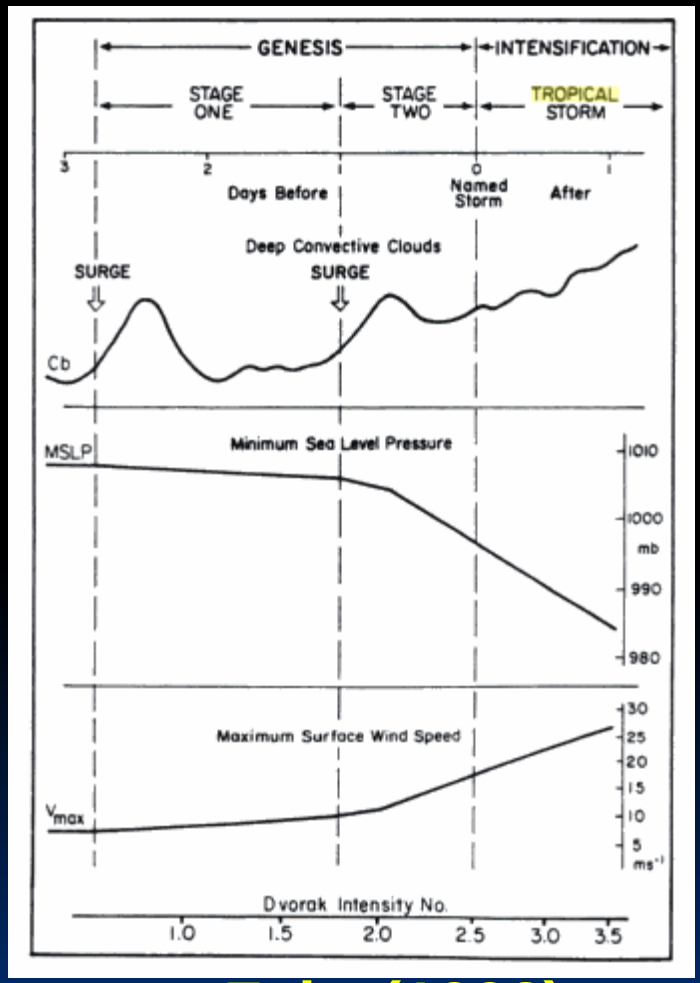
THE ENHANCED SURFACE FLUXES ASSOCIATED WITH STRONG SURFACE WINDS NEAR THE CORE CAN INCREASE THE SUBCLOUD MOIST STATIC ENERGY.

Stage 1-Stage 2 Genesis

INNER CORE MAY ORIGINATE AS A MID-LEVEL MESO-VORTEX (NEAR 700 MB) THAT FORMS IN ASSOCIATION WITH A MESOSCALE CONVECTIVE SYSTEM (MCS)



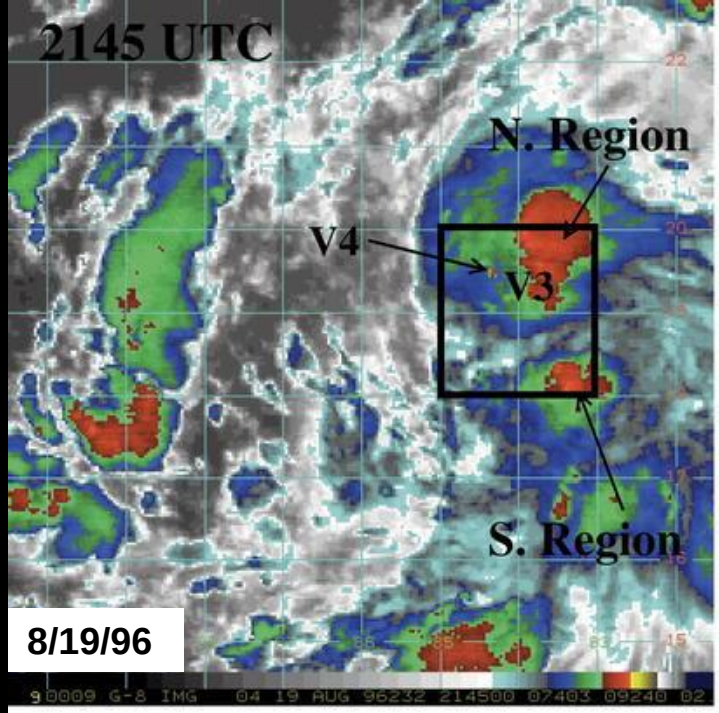
PRE-GORDON DISTURBANCE, 9/13/00 1145 UTC (~24 HOURS PRIOR TO GENESIS)

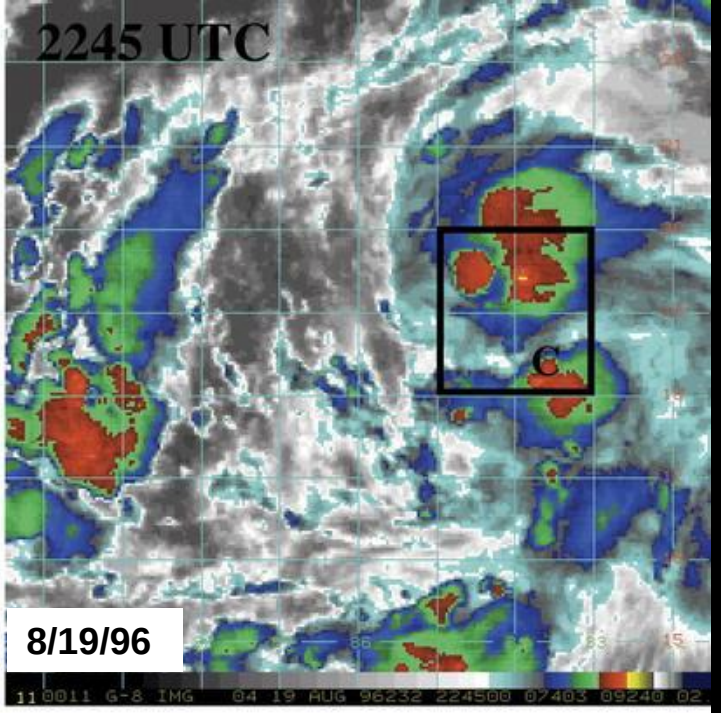


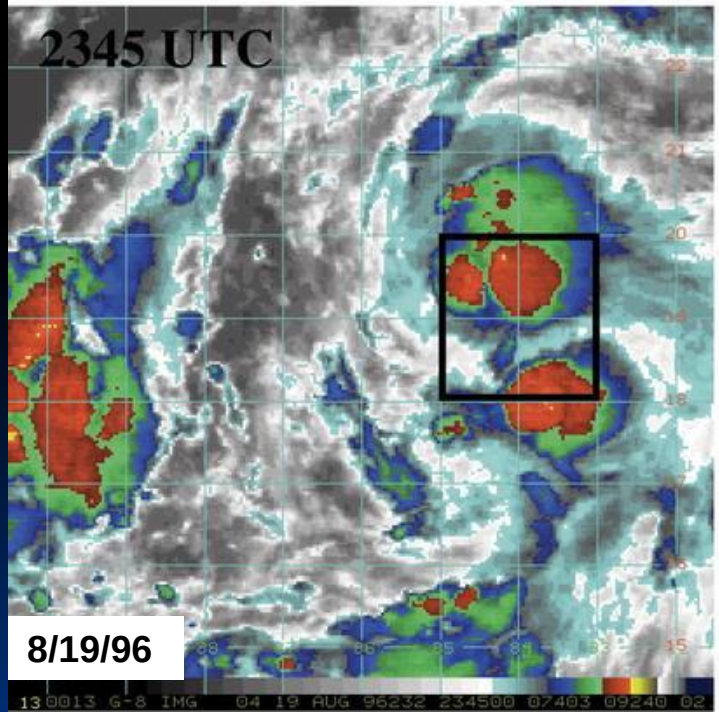
Zehr (1992)

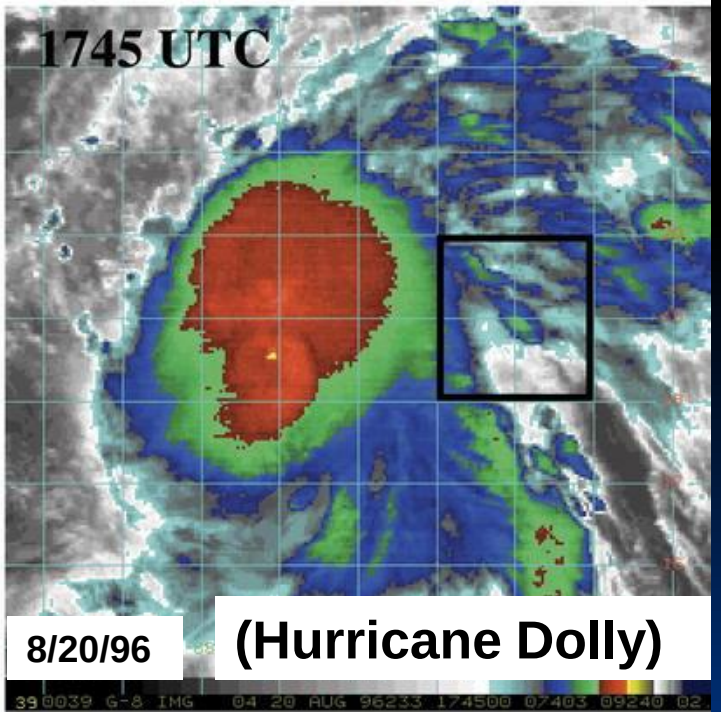
Multiple mid-level mesoscale vortices during genesis stage.

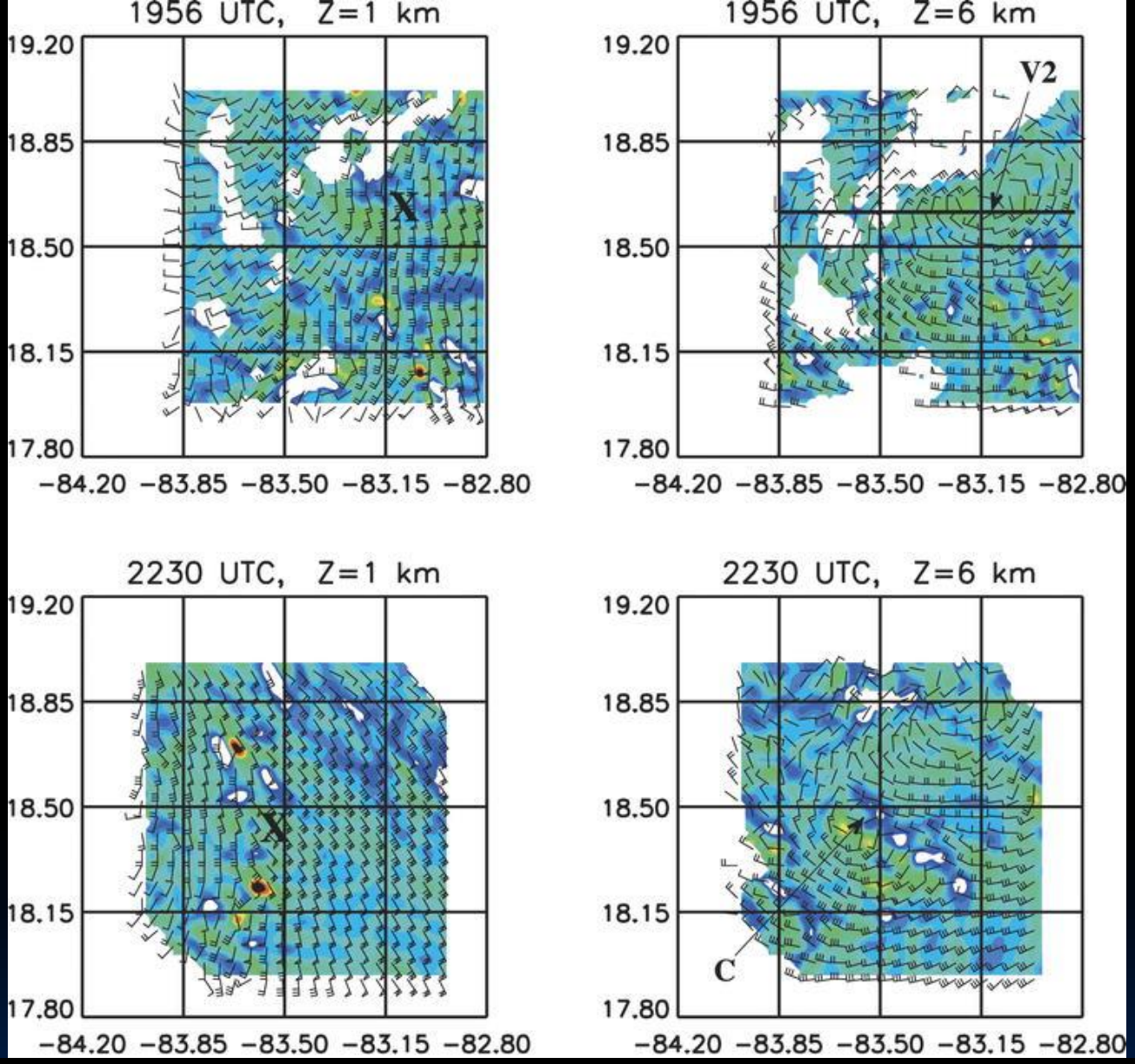
(Reasor et al. 2005 *J. Atmos. Sci.*)









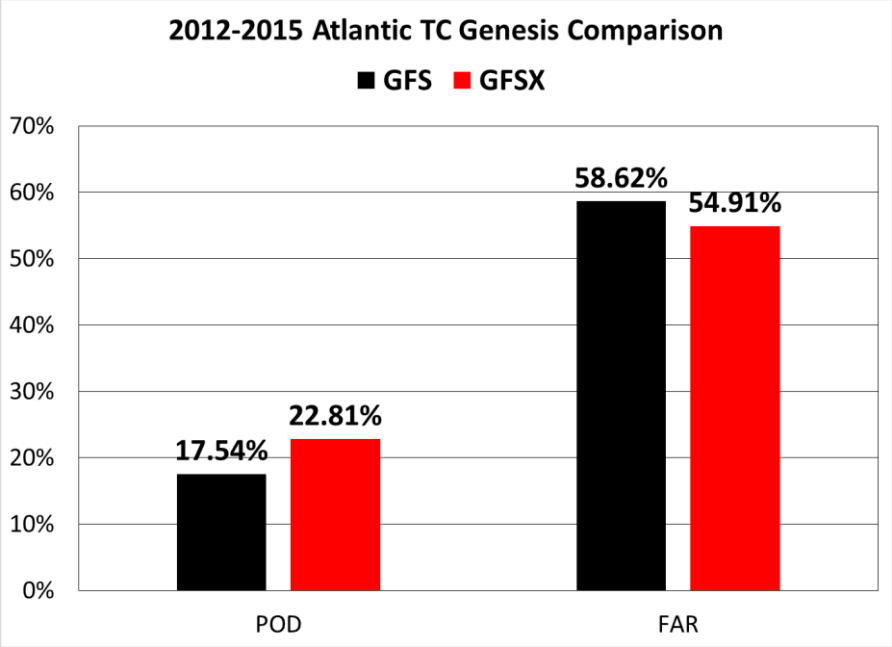


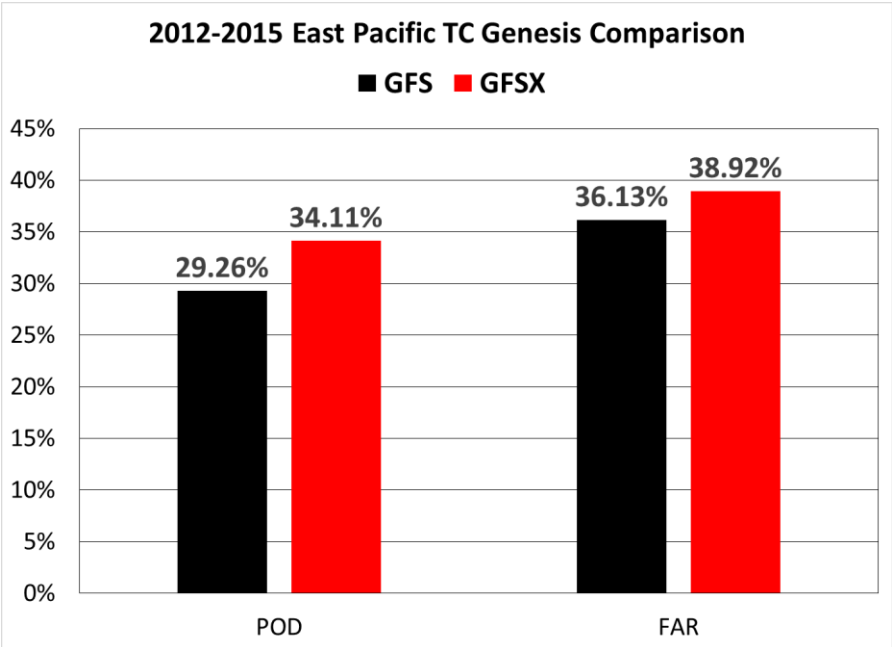
WIND AND VORTICITY WITHIN SOUTHERN CONVECTIVE REGION, 8/19/96

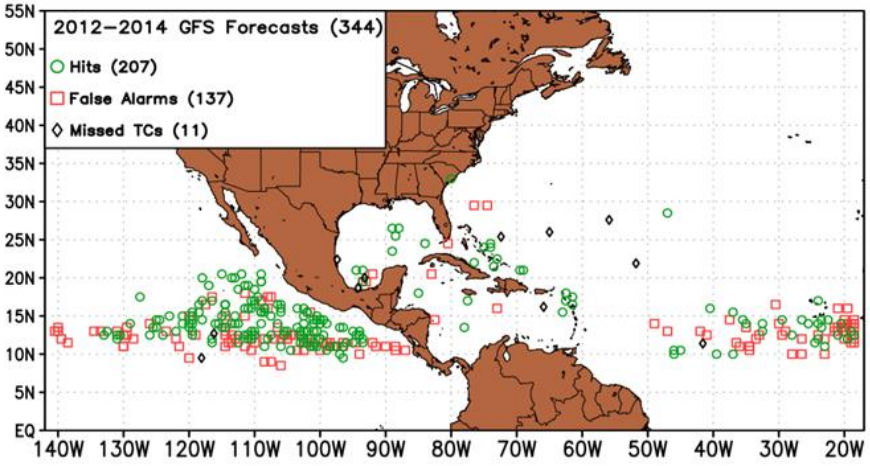
Changes to Global Models relevant to TC genesis forecasting:

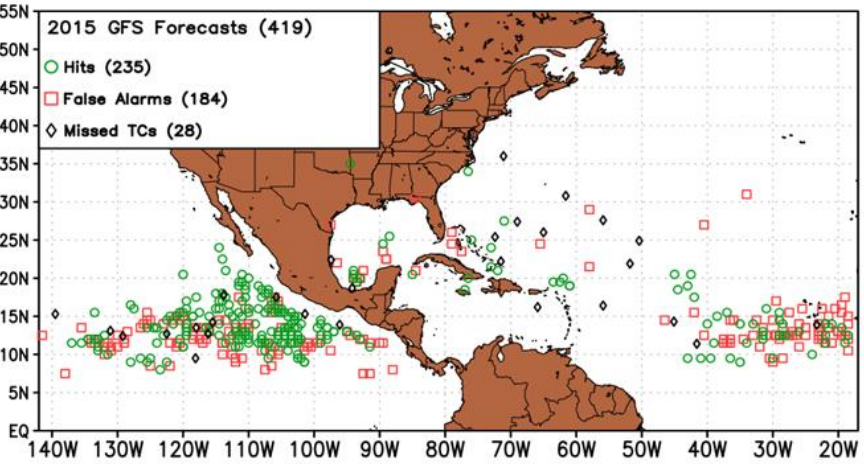
- In May of 2016 (proposed), the data assimilation scheme of the Global Forecast System (GFS) spectral model will change to a 4-D hybrid ensemble variational analysis, and some additional data will be included (AMSU-A radiances and AVHRR winds)
- Based on retrospective runs of this new GFS for 2013-2015, some slight improvement in TC genesis prediction by the GFS is expected this year.
- Next week, the ECMWF global model will also undergo an upgrade, with an increase in horizontal resolution to about 9 km (with the number of vertical levels remaining at 130), and with improvements to the data assimilation and model physics.
- These changes should lead to an improved structural representation of tropical cyclones, but it is not yet known how these changes will affect the ECMWF forecasts of TC genesis.

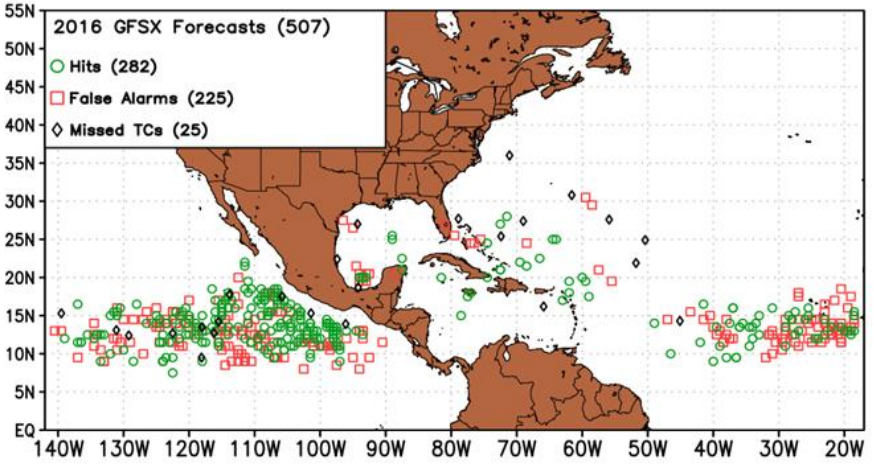
Verification of TC cyclogenesis in the GFSX – comparison to current and previous version of the GFS (based on work done by Dan Halperin and Bob Hart)

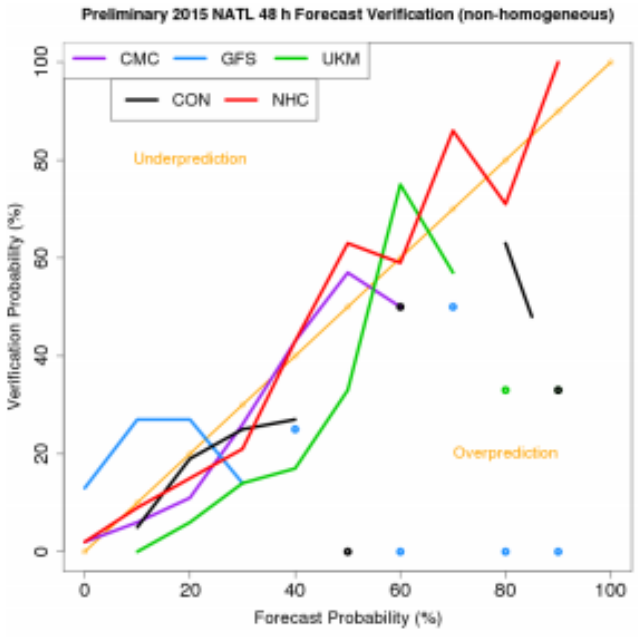




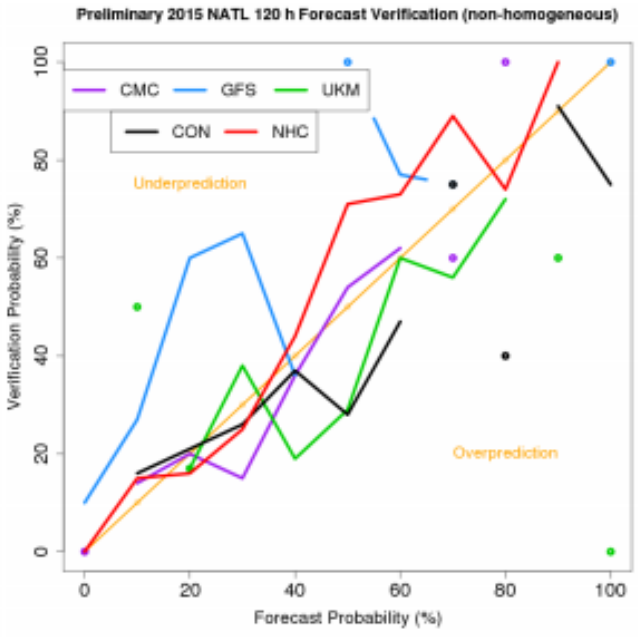

2012–2014 GFS Forecasts (344)
Hits (207)
False Alarms (137)
Missed TCs (11)
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
140W 130W 120W 110W 100W 90W 80W 70W 60W 50W 40W 30W 20W


2015 GFS Forecasts (419)
Hits (235)
False Alarms (184)
Missed TCs (28)
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
140W 130W 120W 110W 100W 90W 80W 70W 60W 50W 40W 30W 20W

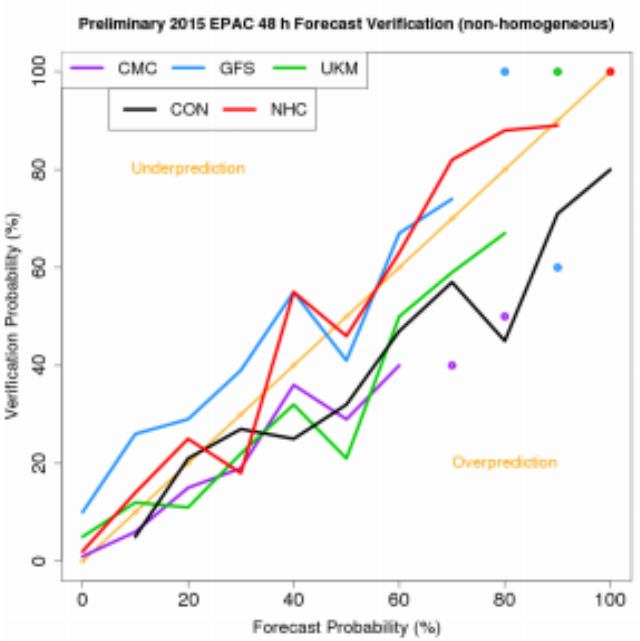

2016 GFSX Forecasts (507)
Hits (282)
False Alarms (225)
Missed TCs (25)
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
140W 130W 120W 110W 100W 90W 80W 70W 60W 50W 40W 30W 20W



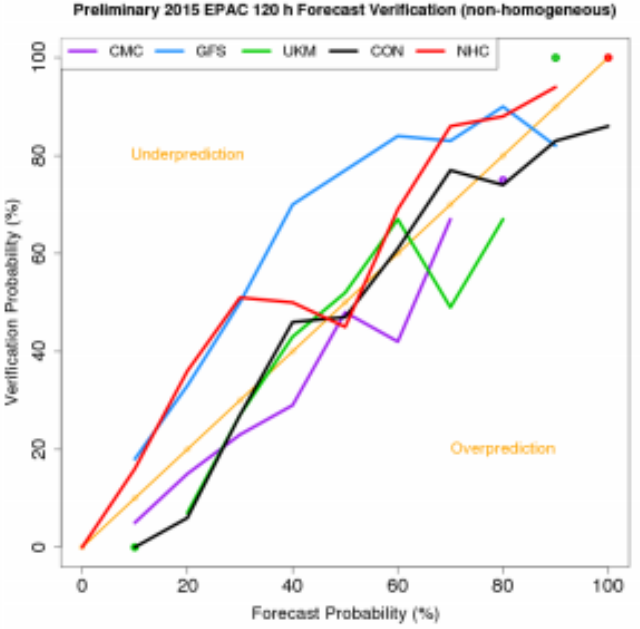
(a) NATL 48 h



(b) NATL 120 h



(c) EPAC 48 h



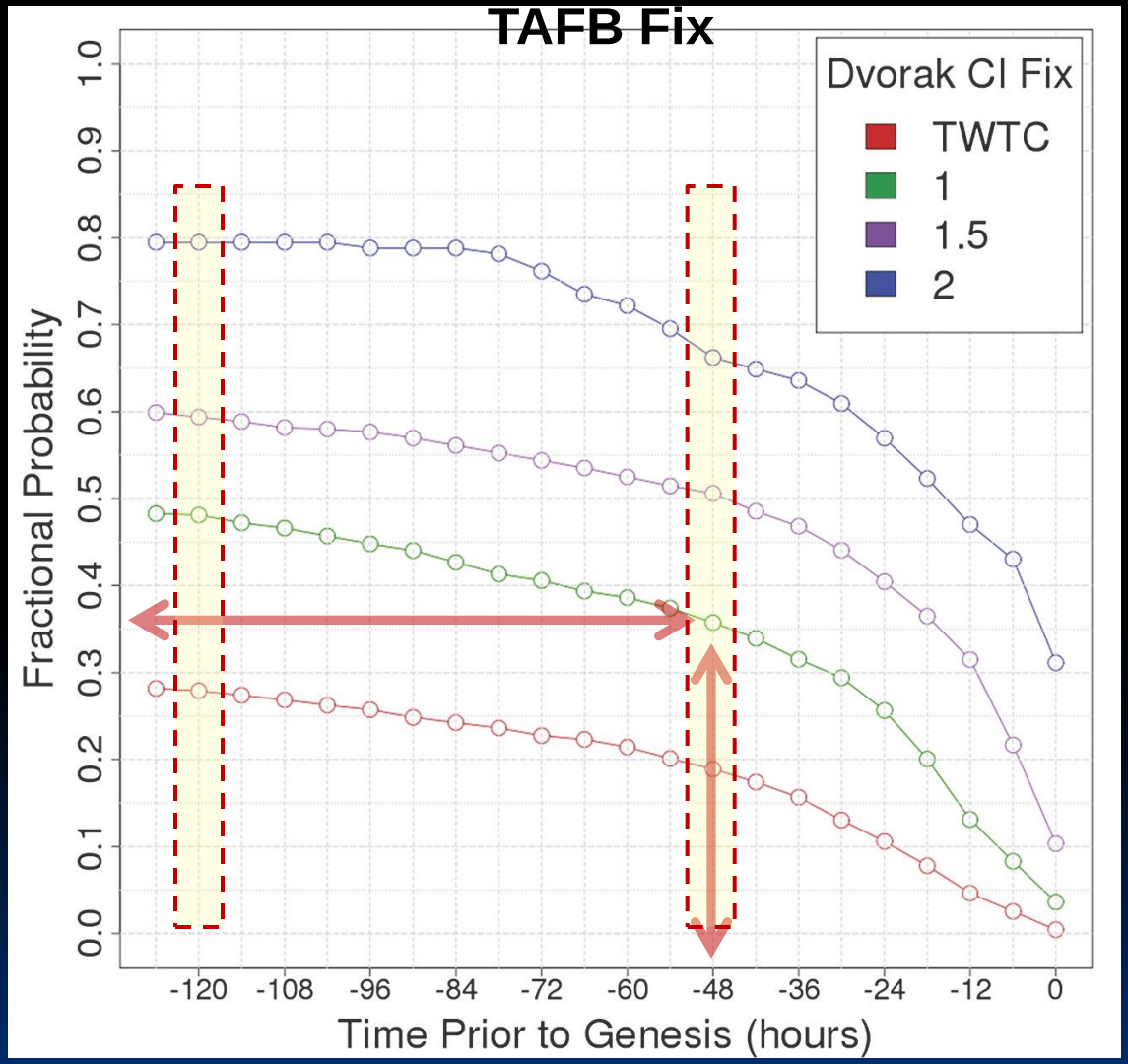
(d) EPAC 120 h

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/

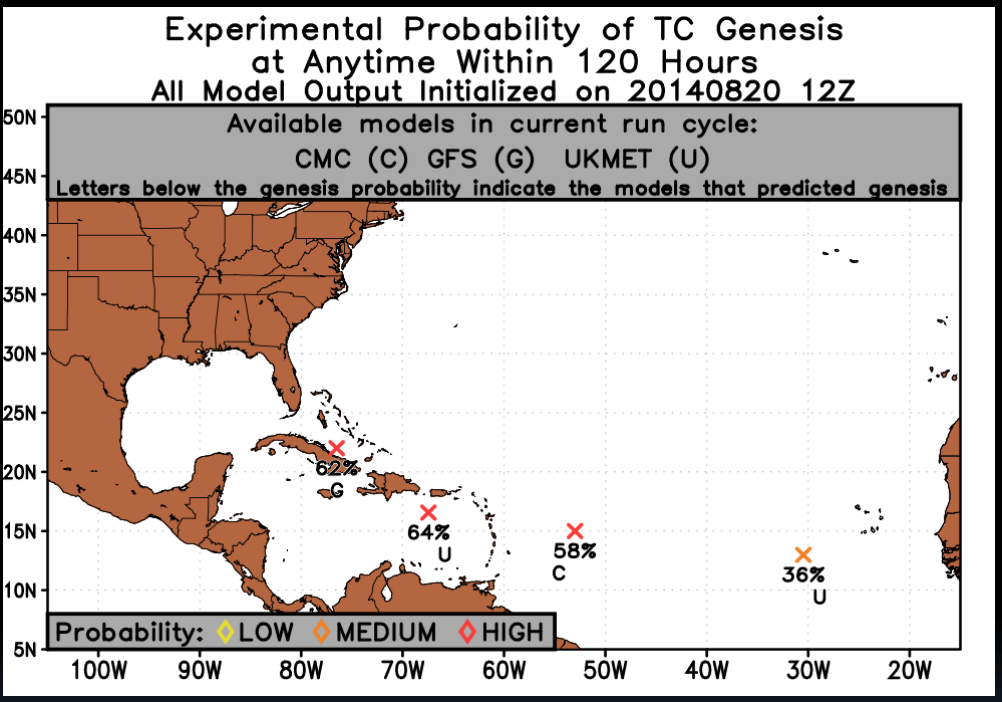
Genesis Probability by Dvorak Number

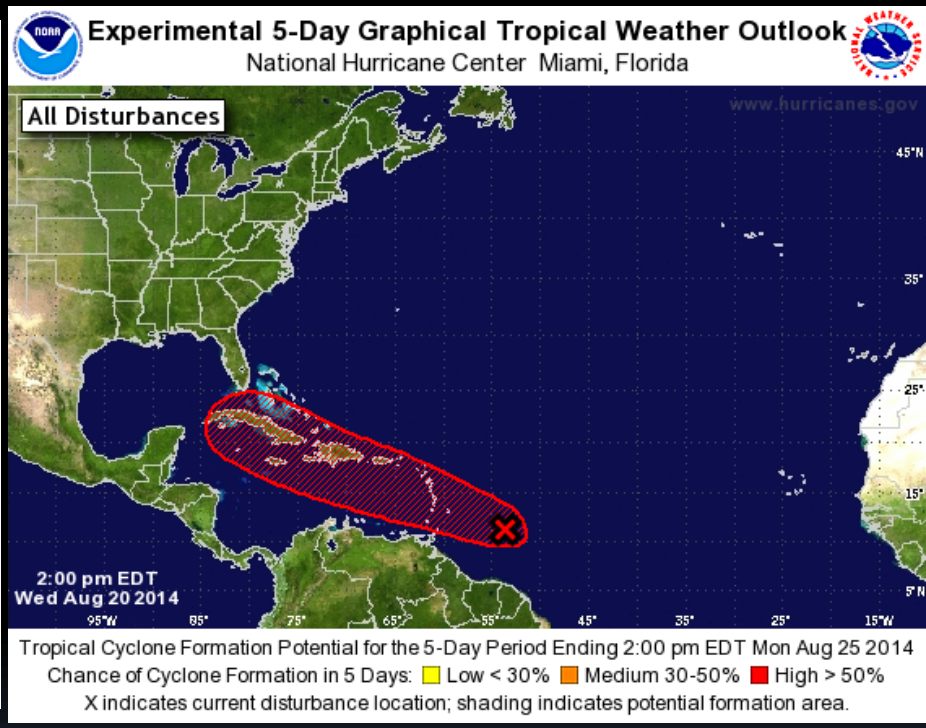
- **Uses Dvorak intensity estimates from all invests/disturbances (both developing and non-developing) from 2001-2011.**
- **Example: Invest with a 1.0 TAFB CI Number has 35% chance of genesis within 48 h.**
- **Real-time guidance at moe.met.fsu.edu/genesis**
- **More information in Cossuth et al. (2013)**



FSU Guidance

(http://moe.met.fsu.edu/modelgen)

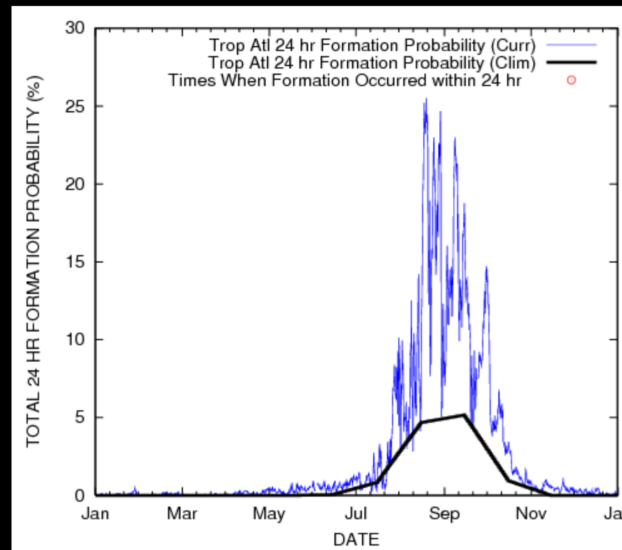




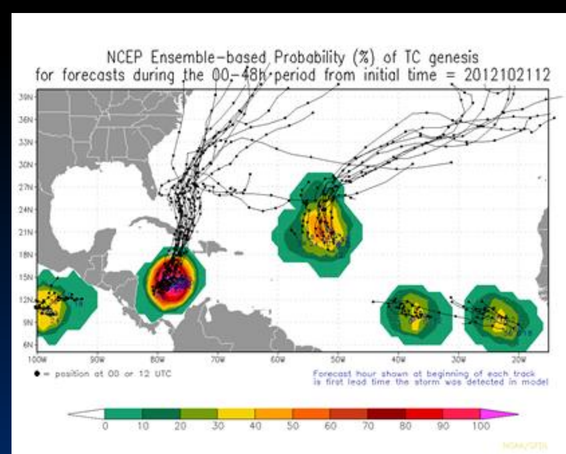
- **Best objective genesis guidance to date**
- **Uses statistics on dynamical model forecasts of genesis to develop probabilities**
- **Multi-model consensus gives most reliable forecasts**
- **Scheme provides guidance on many more systems than are mentioned in the TWO**

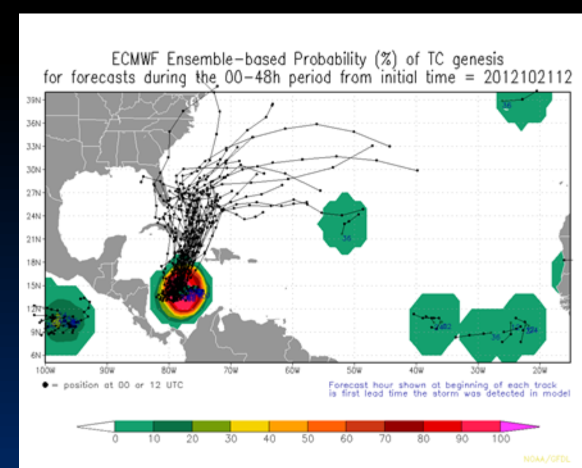
Other Tools

- CIRA Tropical cyclone-based formation probabilities
- Ensemble-based probabilities generated (use consensus of this?)
- Several projects (e.g. Joint Hurricane Testbed), with the goal to provide objective genesis guidance



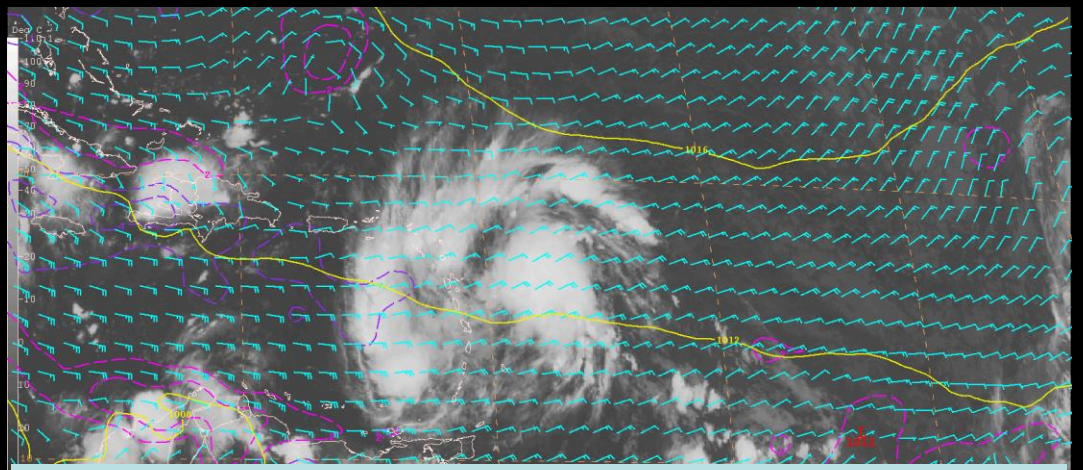

```
          *          ATLANTIC TC GENESIS INDEX          *
          *           AL972013 10/01/13 18 UTC           *

TIME (hr)            0     6    12    18    24    36    48    60    72    84    96   108   120
TCGI (%)                                                45.1                                65.0

HDIV (x10-7s-1)   -3.0  -4.0  -1.0  -3.0  -5.0   0.0  -6.0   1.0  -5.0   0.0  -4.0   0.0   0.0
VORT (x10-6s-1)    1.3   1.6   1.6   1.7   1.6   1.5   1.1   0.8   1.0   0.5   1.1   1.1   1.1
DV24 (x10-6s-1)    0.3   0.0  -0.1  -0.7  -0.5  -0.7  -0.1  -0.3   0.1   0.6   0.0  -0.1  -0.3
VSHD (kt)            5     9    11     9     9    17    19    19    19    26    24    28    27
MLRH (%)            67    67    64    63    67    64    68    62    64    52    54    52    54
PCCD (%)            42   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A
TNUM              1.00   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A   N/A

LAT  (deg N)      16.8  17.2  17.8  18.5  20.3  22.9  25.0  26.3  27.6  28.3  29.2  30.1  31.4
LON  (deg W)      83.0  83.5  84.4  85.1  85.8  87.0  87.4  87.5  86.8  86.5  85.5  84.4  82.9
DTL  (km)          169   172   217   259   132   154   382   358   270   188    56    -5  -140
TRACK SOURCE      AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO  AVNO

Prob of Genesis (t= 48h) =  45.1 is  1.6 times the sample mean ( 27.9)
Prob of Genesis (t=120h) =  65.0 is  1.6 times the sample mean ( 40.3)

------------------------------------------------------------------------------------------------
CONTRIBUTIONS OF CLIMATOLOGY AND INDIVIDUAL PREDICTORS TO TCGI PROBABILITY

                 *******  48-HR ******   ******* 120-HR ******
                     AVG   FCST  %CONT        AVG   FCST  %CONT
CLIM (%)                          27.9                     40.3
HDIV (x10-7s-1)     -1.3   -3.1    9.1       -1.2   -2.2   15.9
DV24 (x10-6s-1)     -0.2   -0.3   -1.8       -0.2   -0.1    3.1
VSHD (kt)           16.8   12.3    4.8       19.0   18.5    0.7
MLRH (%)            64.9   66.0    0.1       61.3   60.8   -0.1
PCCD (%)            29.1   41.8    2.9       28.7   41.8    2.6
TNUM                 0.9    1.0    2.1        0.9    1.0    2.4

%CONT = % contribution to TCGI probability

------------------------------------------------------------------------------------------------
PREDICTOR DEFINITIONS (Averaged Over 500 km Radius)

CLIM = Climatological Probability of Genesis (Source: NHC-TAFB Invest Database)
HDIV = 850-mb GFS Horizontal Divergence
DV24 = 24-hr Change in GFS 850-mb Vorticity (VORT)
VSHD = 850-200 mb GFS Vertical Shear
MLRH = 600-mb GFS Relative Humidity
PCCD = % GOES WV Pixels Colder Than -40C
TNUM = TAFB T-Number
```



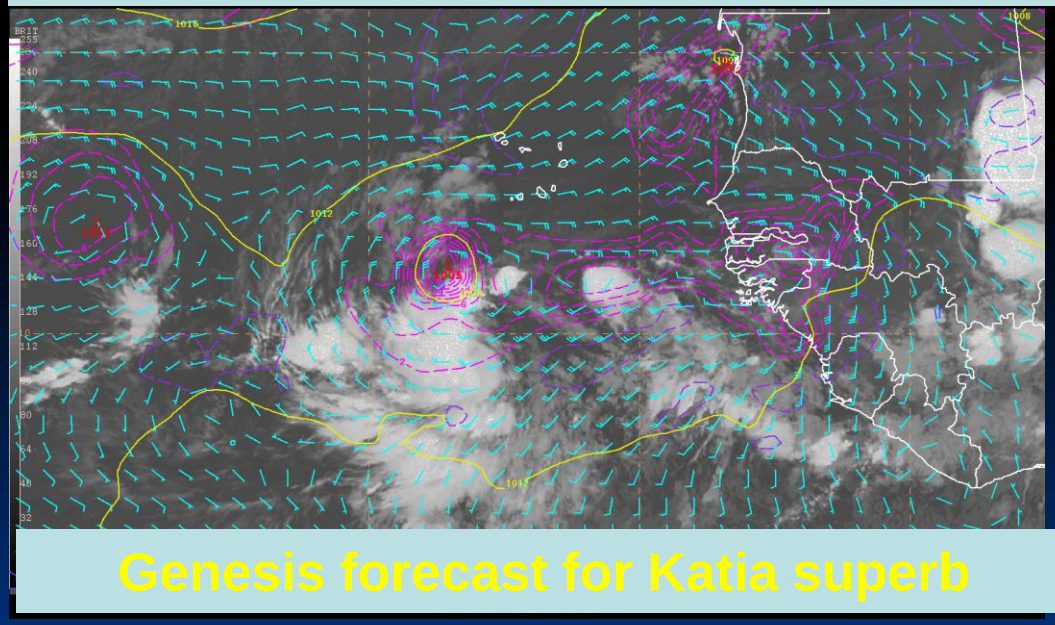


TC Genesis Forecasting at the NHC

- Primary guidance comes from global models but considerable subjectivity involved in NHC genesis forecasts
- Global models can depict TC formation – even in complex cases – fairly realistically
- GFS and ECMWF seem to have greatest skill, but more systematic verification is needed (consensus-based still the best?)
- Models appear to have some geographical biases – they perform better in the eastern Atlantic and western Caribbean, but worse in the Subtropics.
- Models generally 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.



At time of genesis GFS model forecasts poor for Irene several days out

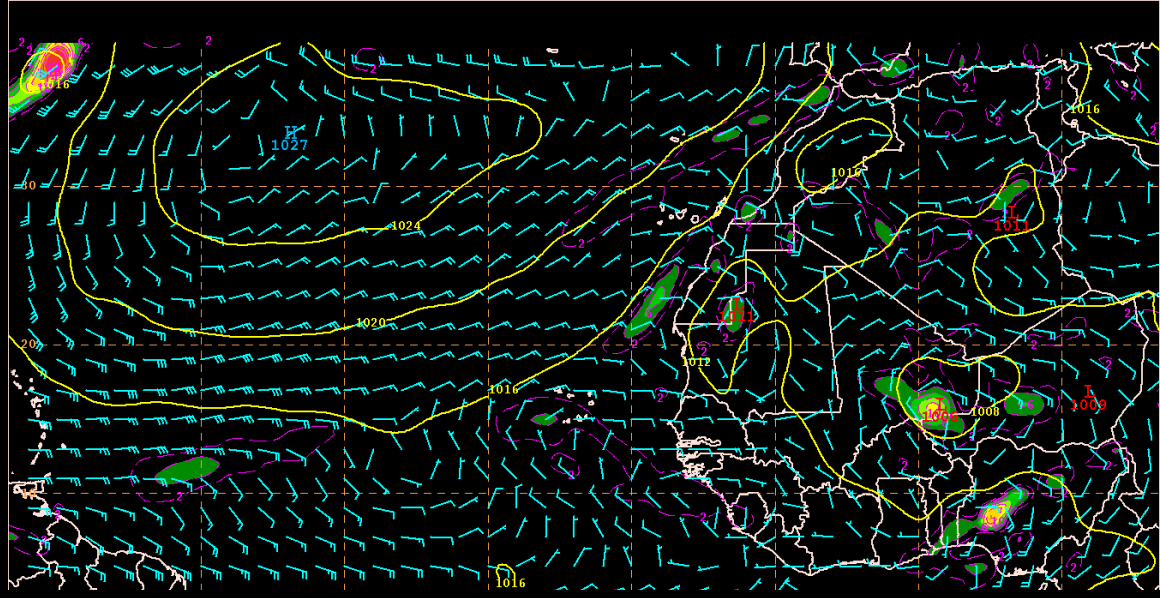


Genesis forecast for Katia superb

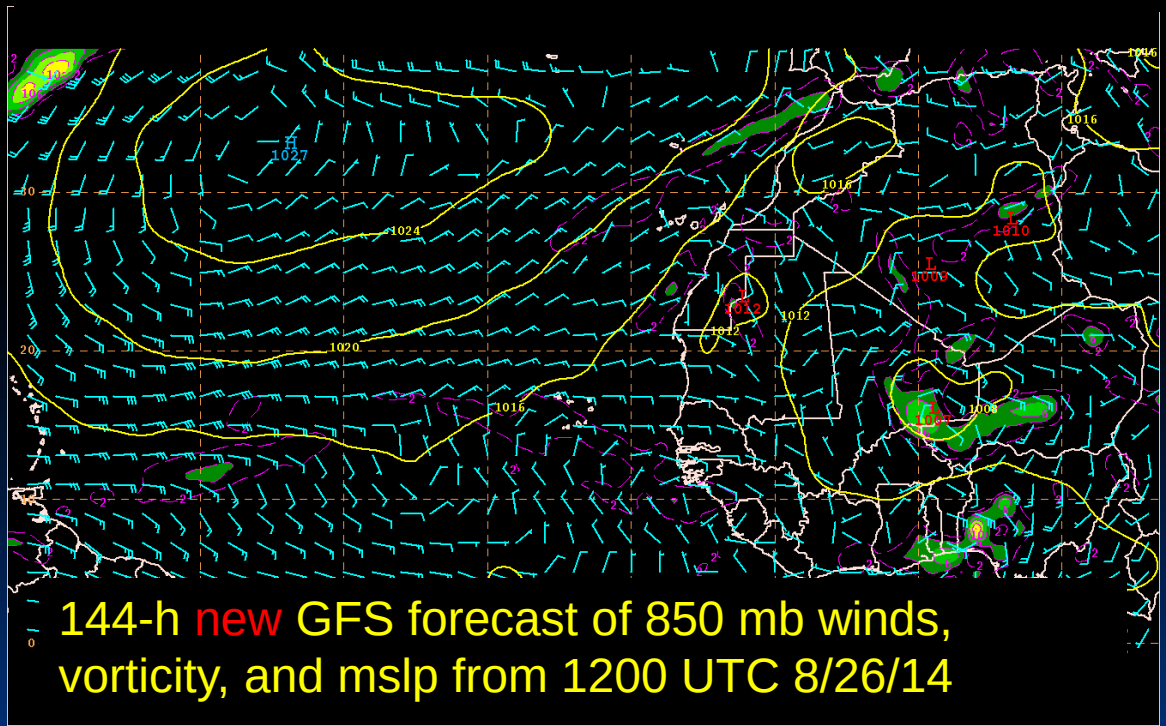
Excerpted from the TWO at 1800 UTC 8/26/14:

"A tropical wave is forecast to move off the west coast of Africa late this week. Conditions appear to be favorable for some development thereafter while the system moves westward at 10 to 15 mph across the eastern Atlantic.

*** Formation chance through 48 hours...low...near 0 percent.**
*** Formation chance through 5 days...medium...40 percent."**

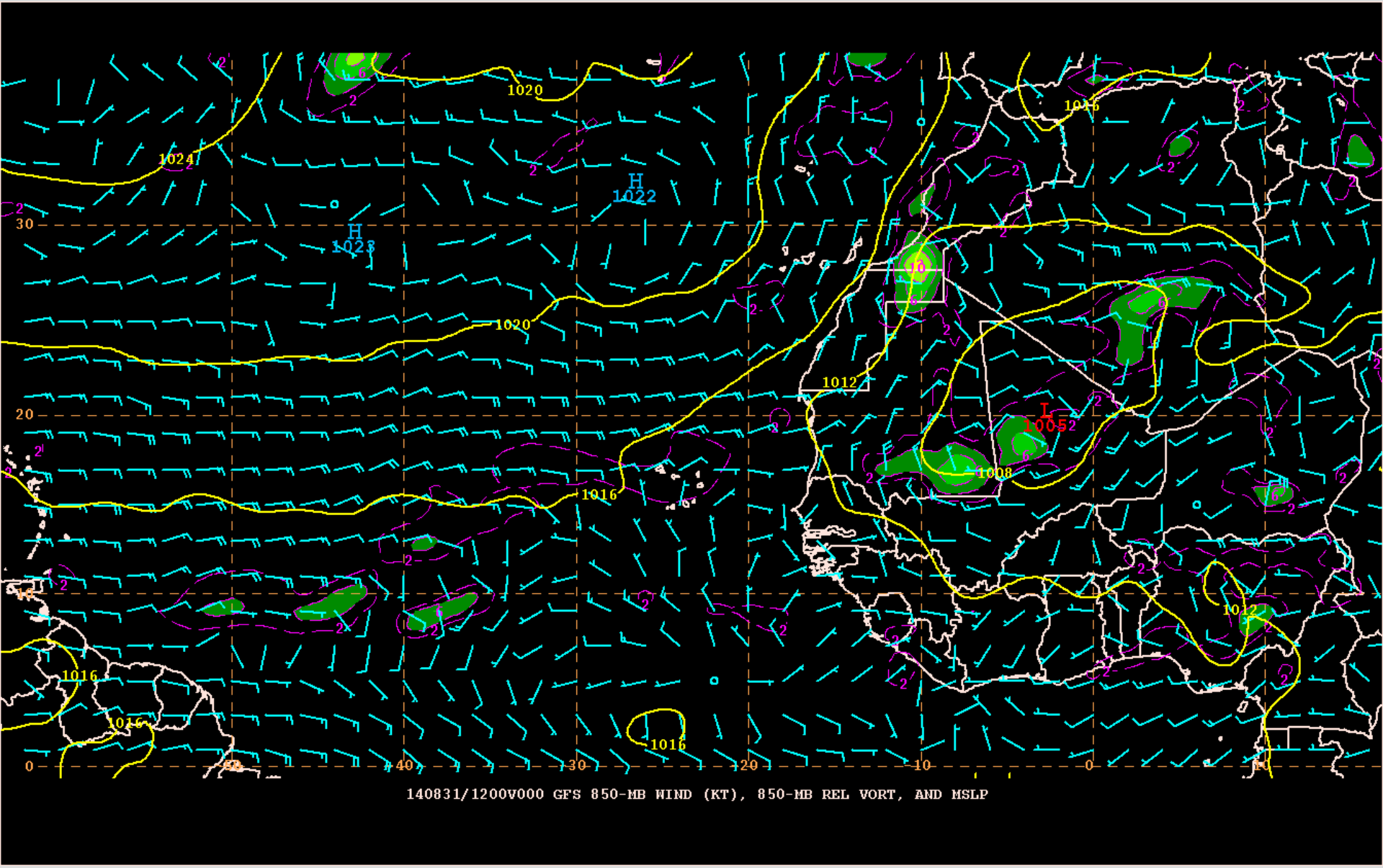


144-h operational GFS forecast of 850 mb winds, vorticity, and mslp from 1200 UTC 8/26/14

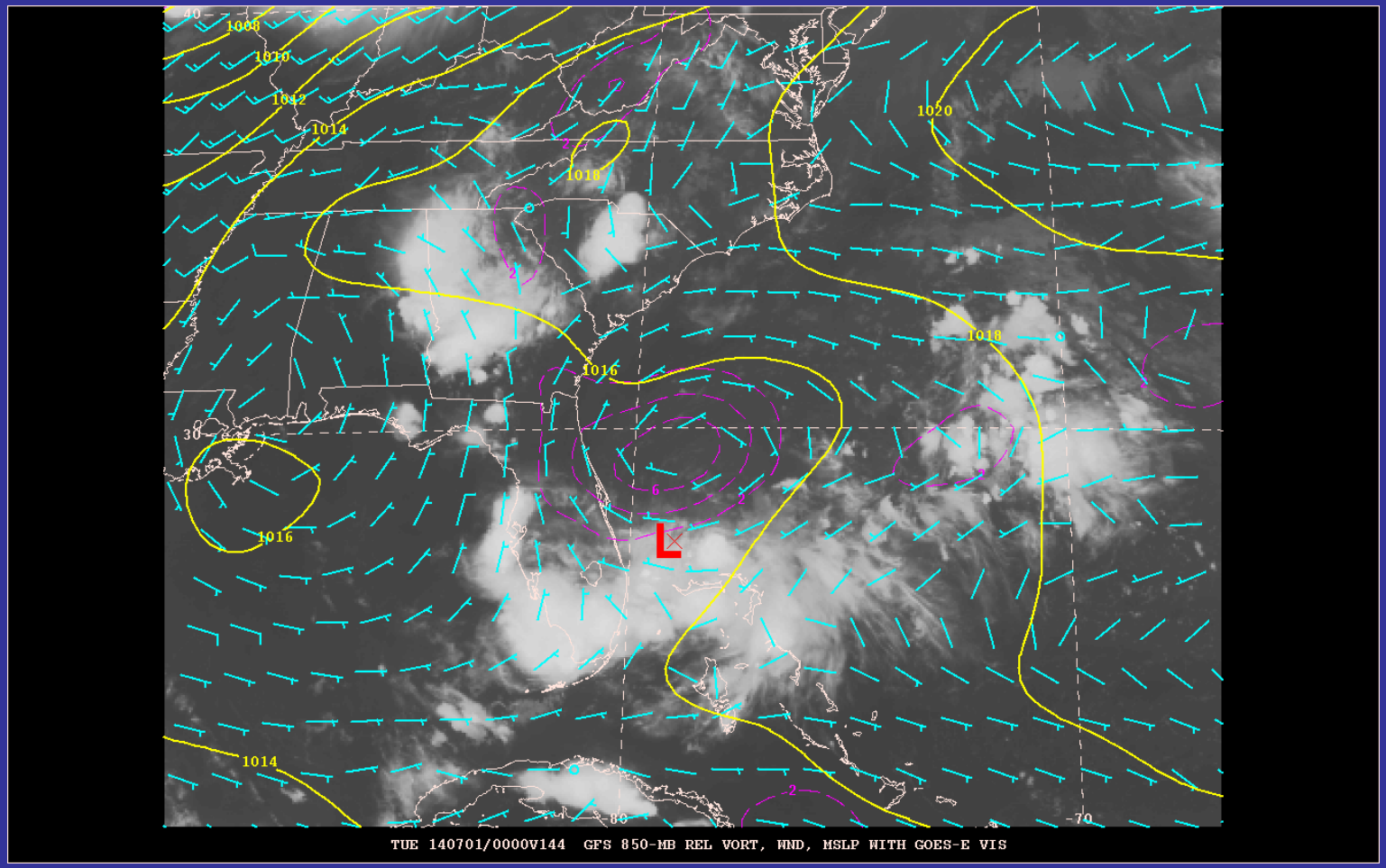


144-h new GFS forecast of 850 mb winds, vorticity, and mslp from 1200 UTC 8/26/14

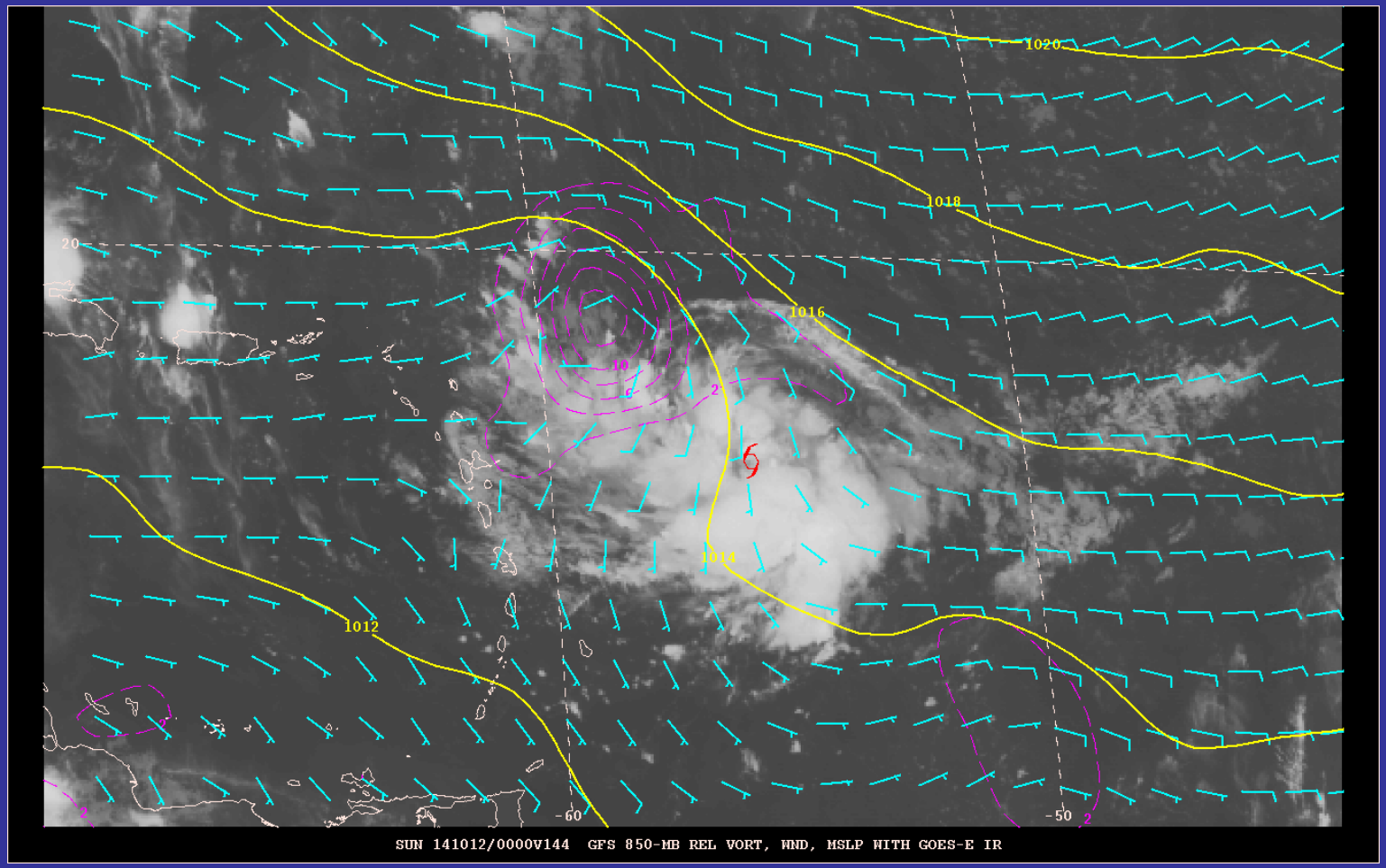
Verifying 850 mb winds, vorticity, and mslp for 120 h: nada!



Arthur – GFS Forecasts Valid 00Z 1 July 2014

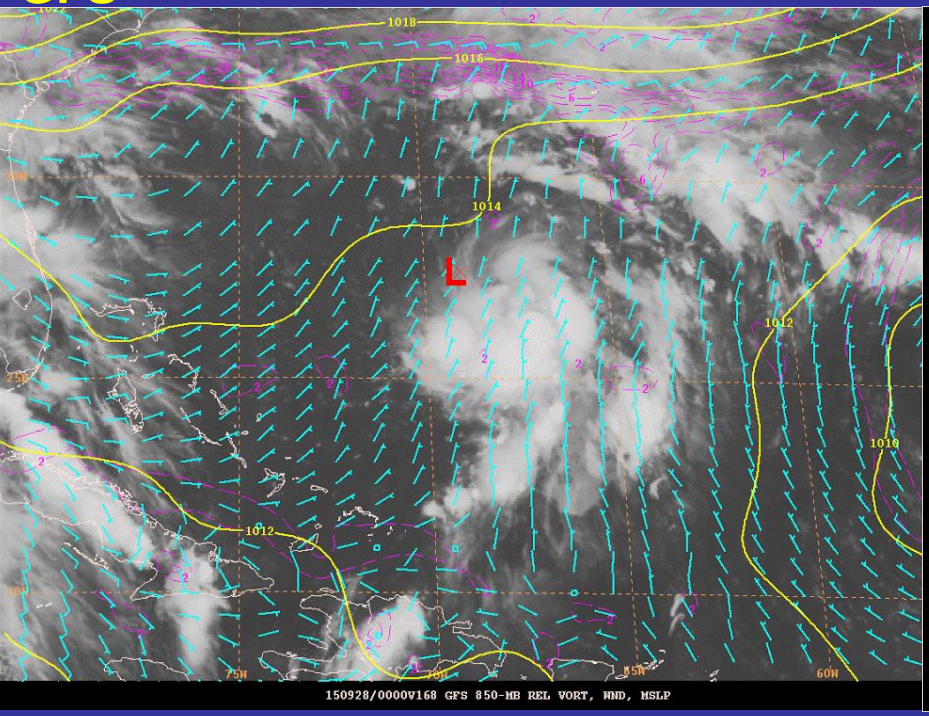


Gonzalo – GFS Forecasts Valid 00Z 12 October 2014

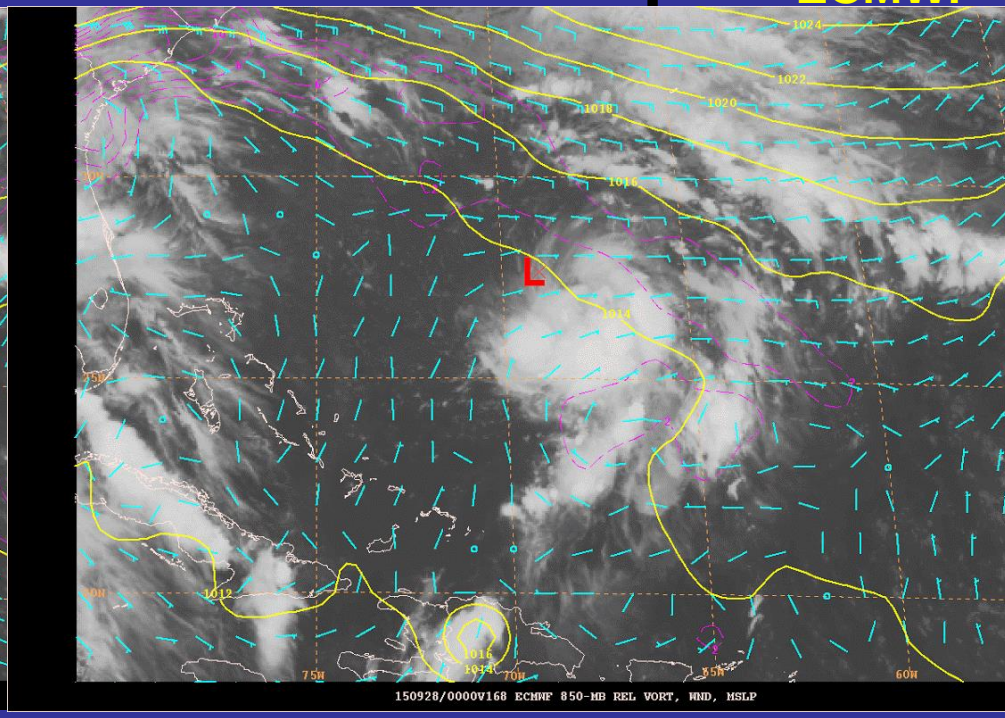


Genesis forecasts for Joaquin

GFS

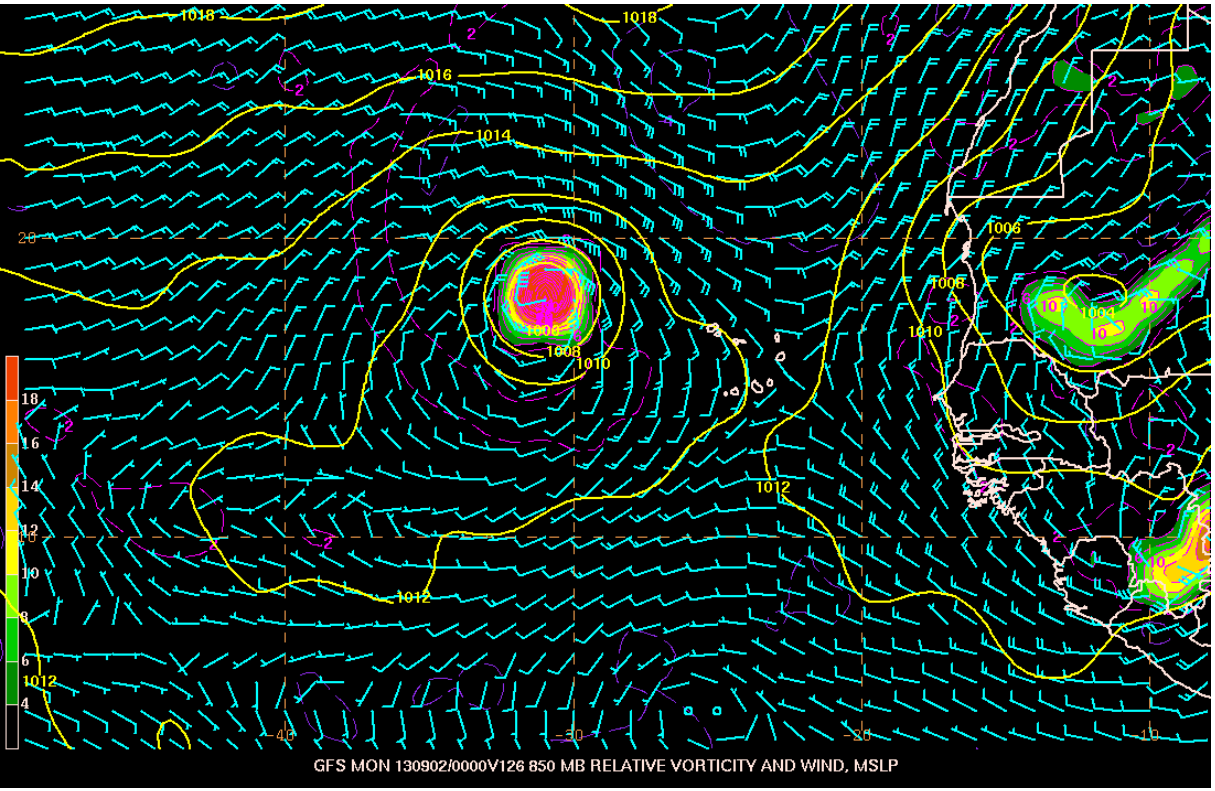


ECMWF



- **Little signal at long-range in GFS, broad low/trough in ECMWF**
- **ECMWF detected genesis about a day earlier than the GFS**

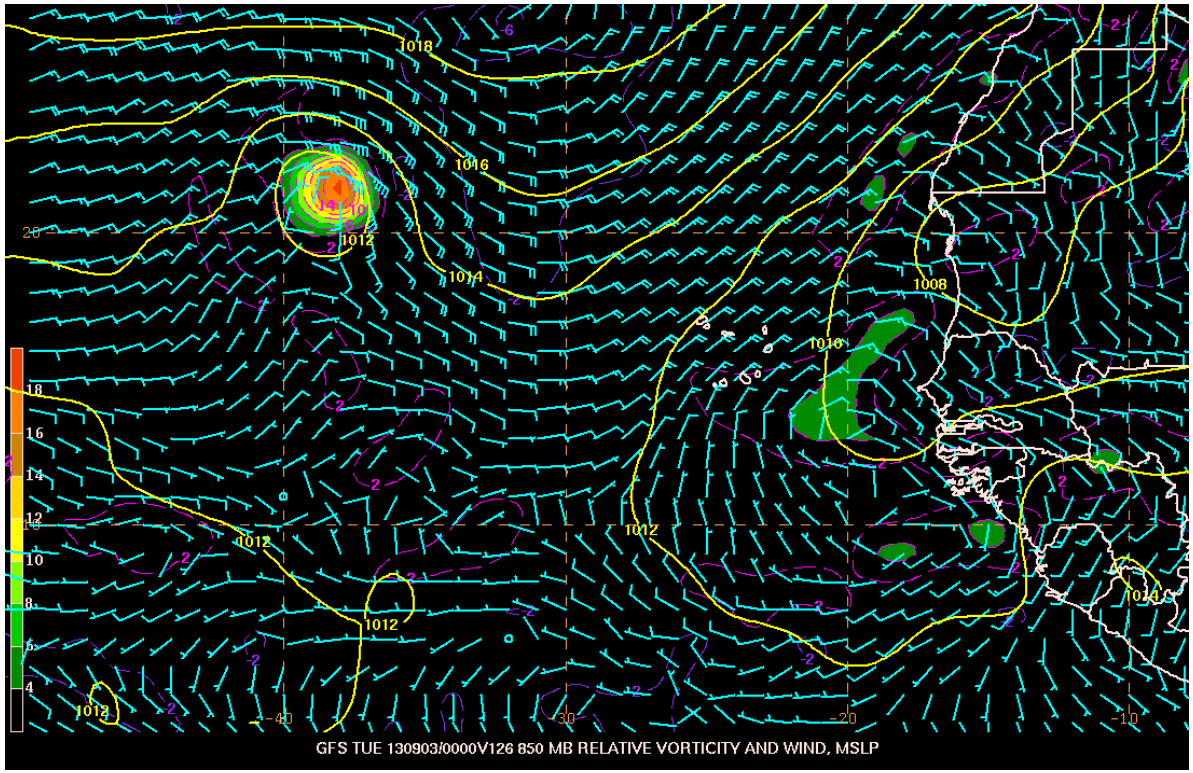
00Z 8/28/13
5-day genesis probability 20%



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

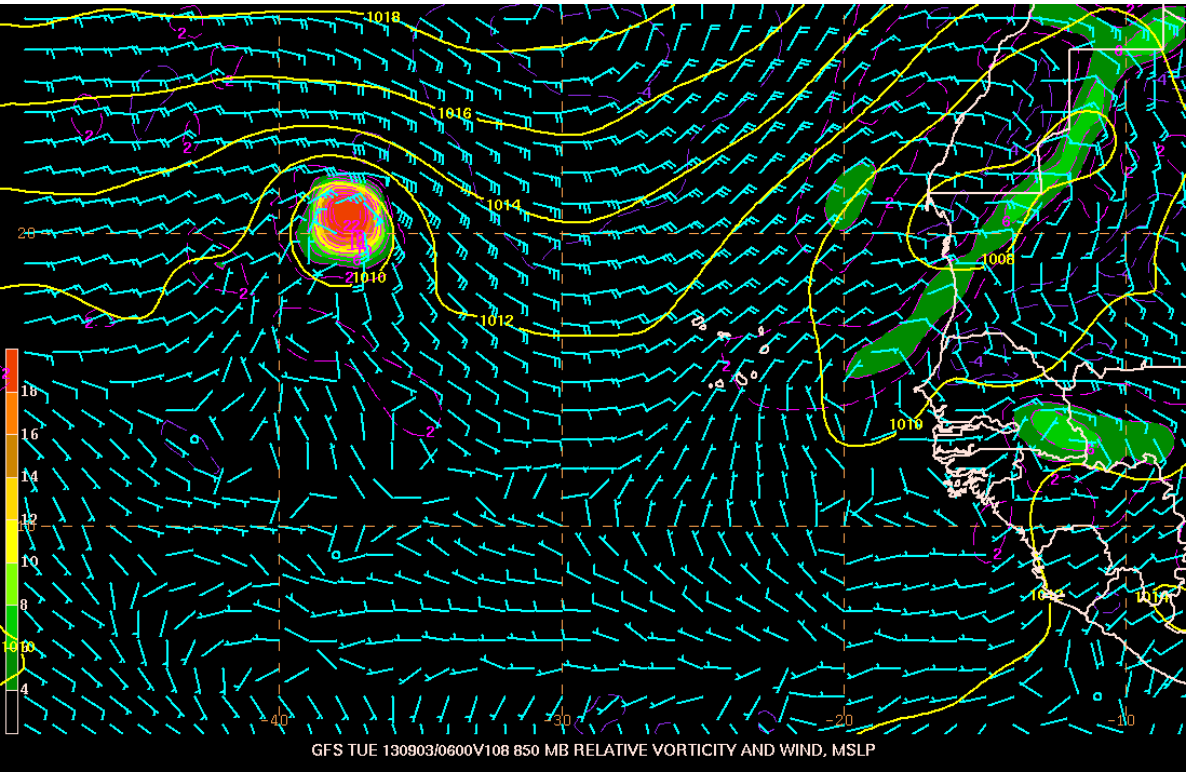
00Z 8/29/13
5-day genesis probability 30%



A TROPICAL WAVE LOCATED OVER WEST AFRICA IS EXPECTED TO MOVE WESTWARD AT 10 TO 15 MPH...AND AN AREA OF LOW PRESSURE COULD FORM AFTER THE WAVE MOVES OFF OF THE COAST ON FRIDAY. SOME DEVELOPMENT OF THIS LOW IS POSSIBLE LATE THIS WEEK OR EARLY THIS WEEKEND BEFORE UPPER-LEVEL WINDS BECOME UNFAVORABLE BY EARLY NEXT WEEK. THIS SYSTEM HAS A LOW CHANCE...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 WHILE IT MOVES NEAR THE CAPE VERDE ISLANDS.

GFS 126-h forecast valid at 00Z 1 September 2013
850-mb relative vorticity and wind and MSLP

00Z 8/30/13
5-day genesis probability 50%

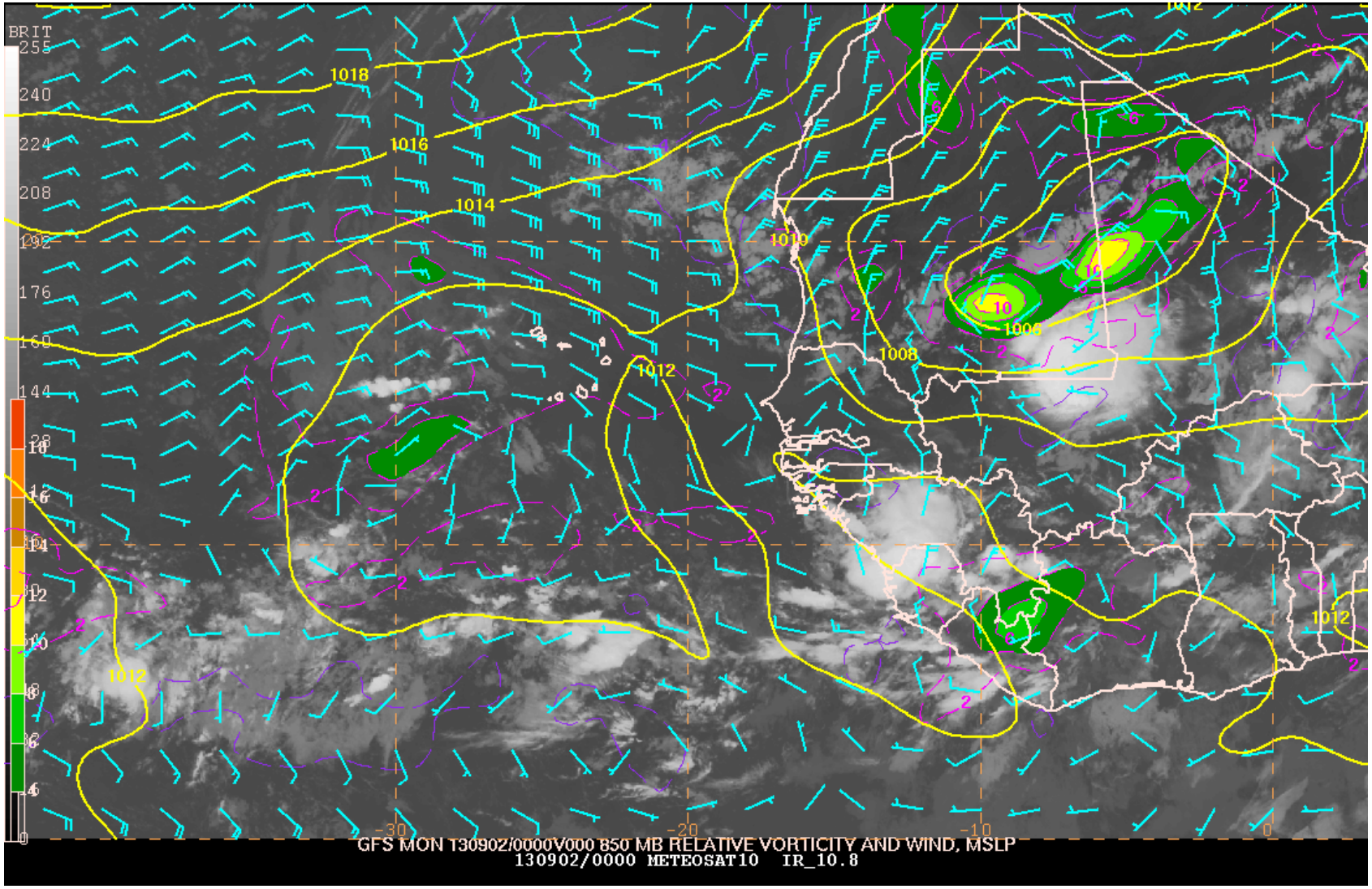


A BROAD AREA OF LOW PRESSURE ASSOCIATED WITH A TROPICAL WAVE IS PRODUCING SHOWERS AND THUNDERSTORMS OVER WESTERN AFRICA. THIS SYSTEM SHOULD MOVE WESTWARD OVER THE FAR EASTERN ATLANTIC OCEAN ON FRIDAY... AND NEAR THE CAPE VERDE ISLANDS LATE SATURDAY. ENVIRONMENTAL CONDITIONS APPEAR CONDUCIVE FOR DEVELOPMENT...AND A TROPICAL DEPRESSION COULD FORM OVER THE WEEKEND. AFTER THAT TIME...THE ENVIRONMENT IS FORECAST TO BECOME LESS CONDUCIVE WHILE THE SYSTEM MOVES TOWARD THE WEST-NORTHWEST OVER THE EASTERN ATLANTIC. THIS SYSTEM HAS A MEDIUM CHANCE...40 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.

GFS 108-h forecast valid at 06Z 3 September 2013

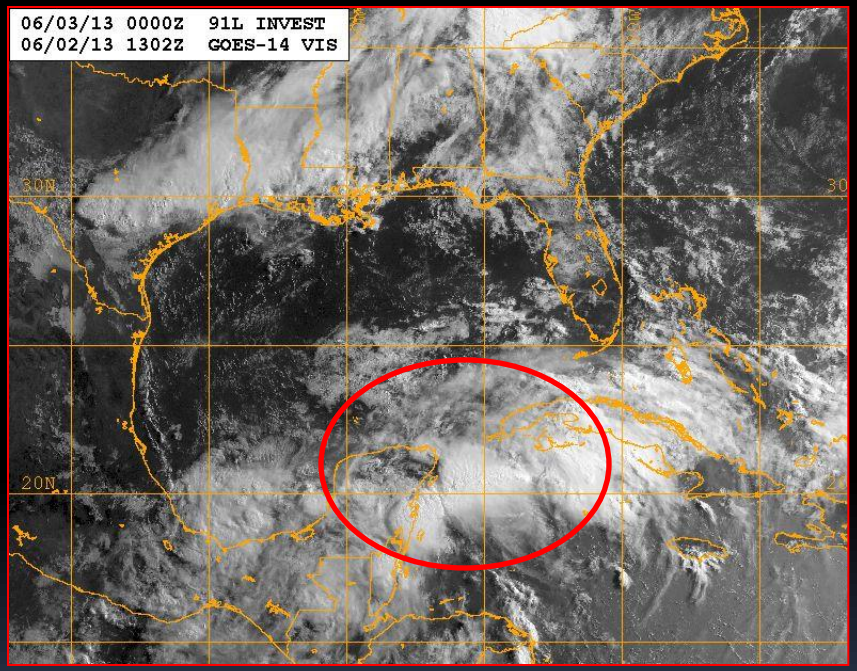
850-mb relative vorticity and wind and MSLP

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



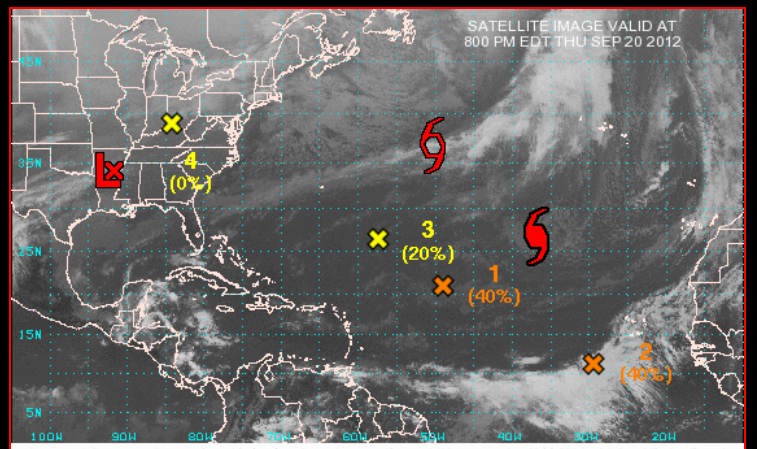
NHC "Invest" Systems

- NHC opens "invests" to monitor suspicious weather systems more carefully
- There are no standards for opening invests unlike for initiating a tropical cyclone package – based on forecaster prerogative
- Guidance is typically run when a cloud system center is apparent (but not always!)
- Users are reminded to be extremely cautious about using parameters associated with particular "invests" in decision-making



Tropical Weather Outlook

- Gives a general synopsis of weather systems in the Atlantic basin that have the potential for tropical cyclone formation during the next <u>48 hours.</u>
- Disturbances are color-coded by their likelihood/probability of formation: low, medium, or high.
- Issued every 6 hours during the hurricane season
  - 0000, 0600, 1200, 1800 UTC
  - 2 AM, 8 AM, 2 PM, 8 PM EDT



000
ABNT20 KNHC 111736
TWOAT
TROPICAL WEATHER OUTLOOK
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL
200 PM EDT SAT SEP 11 2010

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

THE NATIONAL HURRICANE CENTER IS ISSUING ADVISORIES ON TROPICAL STORM IGOR...LOCATED ABOUT 1030 MILES WEST OF THE CAPE VERDE ISLANDS.

SHOWERS AND THUNDERSTORMS HAVE CHANGED LITTLE IN ASSOCIATION WITH A BROAD AREA OF LOW PRESSURE LOCATED OVER THE EASTERN CARIBBEAN SEA. ENVIRONMENTAL CONDITIONS APPEAR FAVORABLE FOR DEVELOPMENT...AND A TROPICAL DEPRESSION COULD FORM AS THE SYSTEM MOVES WESTWARD INTO THE CENTRAL AND WESTERN CARIBBEAN SEA. THERE IS A HIGH CHANCE...60 PERCENT...OF THIS SYSTEM BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS. REGARDLESS OF DEVELOPMENT...LOCALLY HEAVY RAINFALL IS POSSIBLE IN THE NORTHERN LEEWARD ISLANDS...PUERTO RICO...THE VIRGIN ISLANDS...AND HISPANIOLA DURING THE NEXT DAY OR SO. THESE RAINS COULD CAUSE LIFE-THREATENING FLASH FLOODS AND MUD SLIDES... ESPECIALLY IN MOUNTAINOUS TERRAIN.

SATELLITE IMAGERY AND UPPER-AIR OBSERVATIONS INDICATE THAT THE VIGOROUS TROPICAL WAVE AND ASSOCIATED LOW PRESSURE AREA NEAR THE WEST COAST OF AFRICA HAVE BECOME BETTER ORGANIZED DURING THE PAST SEVERAL HOURS. SURFACE PRESSURES ARE QUITE LOW...AND A TROPICAL DEPRESSION COULD FORM OVER THE NEXT COUPLE OF DAYS AS THIS SYSTEM MOVES TOWARD THE WEST OR WEST-NORTHWEST AT 10 TO 15 MPH. THERE IS A MEDIUM CHANCE...50 PERCENT...OF THIS SYSTEM BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS.

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

$$
FORECASTER BLAKE/BRENNAN

5-day Genesis Product

ZCZC MIATWOAT ALL
TTAA00 KNHC DDHHMM

TROPICAL WEATHER OUTLOOK
NWS NATIONAL HURRICANE CENTER MIAMI FL
800 AM EDT SUN SEP 8 2013

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

1. SHOWERS AND THUNDERSTORMS ARE GRADUALLY BECOMING BETTER ORGANIZED NEAR A LOW PRESSURE SYSTEM CENTERED ABOUT 325 MILES EAST-SOUTHEAST OF THE SOUTHERN CAPE VERDE ISLANDS. ENVIRONMENTAL CONDITIONS APPEAR CONDUCIVE FOR FURTHER DEVELOPMENT...AND A TROPICAL DEPRESSION COULD FORM DURING THE NEXT DAY OR SO WHILE THE DISTURBANCE MOVES WEST-NORTHWESTWARD AT ABOUT 10 MPH TOWARD THE CAPE VERDE ISLANDS. THIS SYSTEM HAS A HIGH CHANCE...70 PERCENT... OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A HIGH CHANCE...90 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. INTERESTS IN THE CAPE VERDE ISLANDS SHOULD MONITOR THE PROGRESS OF THIS SYSTEM...AND TROPICAL STORM WATCHES OR WARNINGS COULD BE REQUIRED IF A DEPRESSION FORMS. REGARDLESS OF TROPICAL CYCLONE FORMATION...HEAVY RAINFALL AND GUSTY WINDS ARE POSSIBLE IN THE CAPE VERDE ISLANDS BY LATER TODAY.

2. A BROAD LOW PRESSURE AREA...THE REMNANTS OF GABRIELLE...IS LOCATED A FEW HUNDRED MILES NORTHEAST OF THE SOUTHEASTERN BAHAMAS AND IS PRODUCING DISORGANIZED SHOWERS AND THUNDERSTORMS. UPPER-LEVEL WINDS ARE NOT EXPECTED TO BE PARTICULARLY CONDUCIVE FOR DEVELOPMENT DURING THE NEXT FEW DAYS WHILE THE SYSTEM MOVES NORTHEASTWARD AT ABOUT 10 MPH. THIS SYSTEM HAS A LOW CHANCE...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.

OTHER SYSTEMS WITH DEVELOPMENT POTENTIAL BEYOND 48 HOURS...

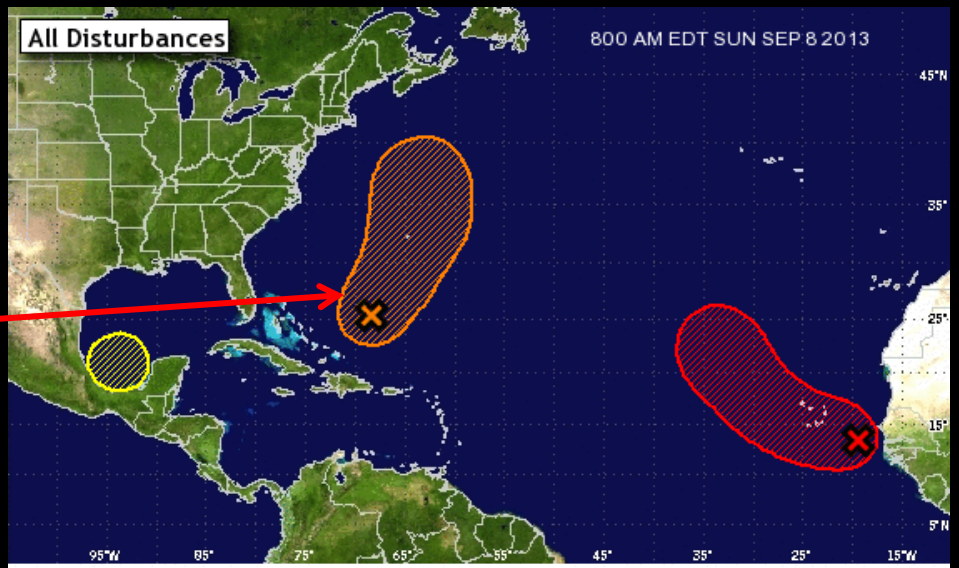
3. A TROUGH OF LOW PRESSURE COULD FORM OVER THE EXTREME SOUTHWESTERN GULF OF MEXICO AND BAY OF CAMPECHE IN A FEW DAYS...AND SOME DEVELOPMENT OF THIS SYSTEM IS POSSIBLE LATER THIS WEEK. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

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 BERG

THIS SYSTEM HAS A LOW CHANCE… 10 PERCENT…OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS…

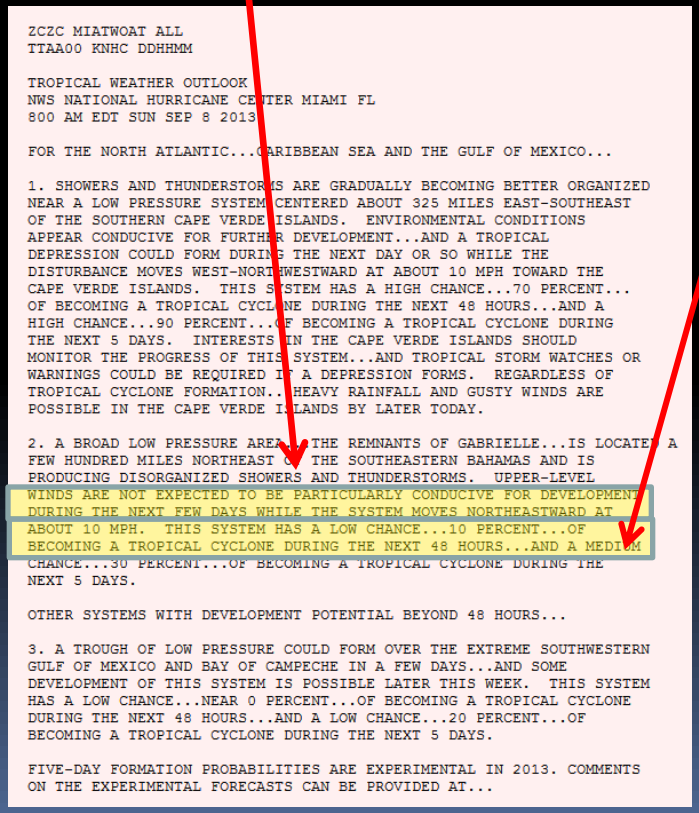


Tropical Cyclone Formation Potential for Five-Day Period Ending 800 AM EDT FRI SEP 13 2013
Chance of Formation: Low < 30% Medium 30-50% High > 50%
X indicates current disturbance location; shading indicates potential formation area.

THIS SYSTEM HAS A MEDIUM CHANCE… 40 PERCENT…OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

5-day Genesis Product

Disturbance	1-2 Day (%)	3-5 Day (%)	1-5 Day (%)
#1	70	20	90
#2	10	20	30
#3	0	20	20



ZCZC MIATWOAT ALL
TTAA00 KNHC DDHHMM

TROPICAL WEATHER OUTLOOK
NWS NATIONAL HURRICANE CENTER MIAMI FL
800 AM EDT SUN SEP 8 2013

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

1. SHOWERS AND THUNDERSTORMS ARE GRADUALLY BECOMING BETTER ORGANIZED NEAR A LOW PRESSURE SYSTEM CENTERED ABOUT 325 MILES EAST-SOUTHEAST OF THE SOUTHERN CAPE VERDE ISLANDS. ENVIRONMENTAL CONDITIONS APPEAR CONDUCIVE FOR FURTHER DEVELOPMENT...AND A TROPICAL DEPRESSION COULD FORM DURING THE NEXT DAY OR SO WHILE THE DISTURBANCE MOVES WEST-NORTHWESTWARD AT ABOUT 10 MPH TOWARD THE CAPE VERDE ISLANDS. THIS SYSTEM HAS A HIGH CHANCE...70 PERCENT... OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A HIGH CHANCE...90 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS. INTERESTS IN THE CAPE VERDE ISLANDS SHOULD MONITOR THE PROGRESS OF THIS SYSTEM...AND TROPICAL STORM WATCHES OR WARNINGS COULD BE REQUIRED IF A DEPRESSION FORMS. REGARDLESS OF TROPICAL CYCLONE FORMATION...HEAVY RAINFALL AND GUSTY WINDS ARE POSSIBLE IN THE CAPE VERDE ISLANDS BY LATER TODAY.

2. A BROAD LOW PRESSURE AREA...THE REMNANTS OF GABRIELLE...IS LOCATED A FEW HUNDRED MILES NORTHEAST OF THE SOUTHEASTERN BAHAMAS AND IS PRODUCING DISORGANIZED SHOWERS AND THUNDERSTORMS. UPPER-LEVEL WINDS ARE NOT EXPECTED TO BE PARTICULARLY CONDUCIVE FOR DEVELOPMENT DURING THE NEXT FEW DAYS WHILE THE SYSTEM MOVES NORTHEASTWARD AT ABOUT 10 MPH. THIS SYSTEM HAS A LOW CHANCE...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.

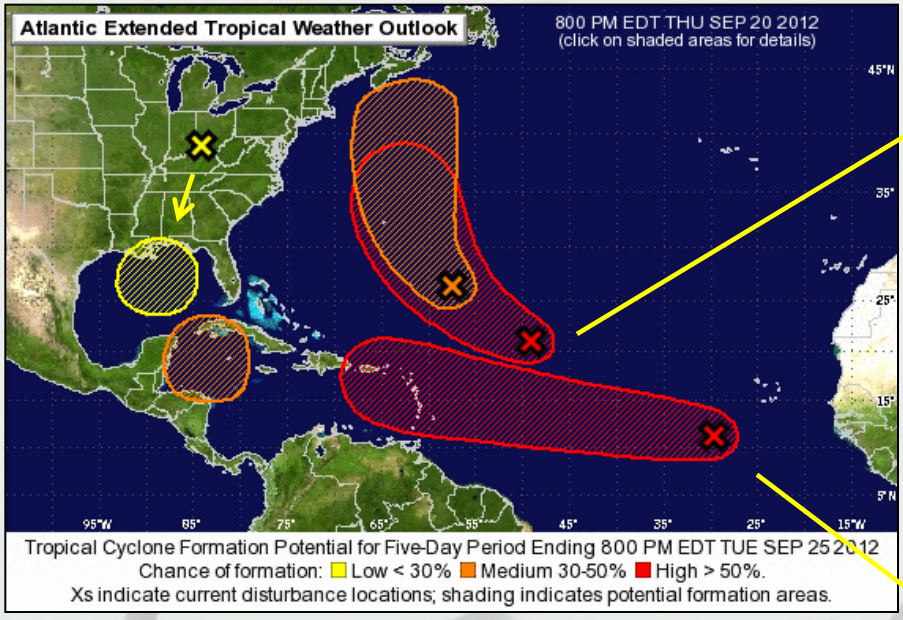
OTHER SYSTEMS WITH DEVELOPMENT POTENTIAL BEYOND 48 HOURS...

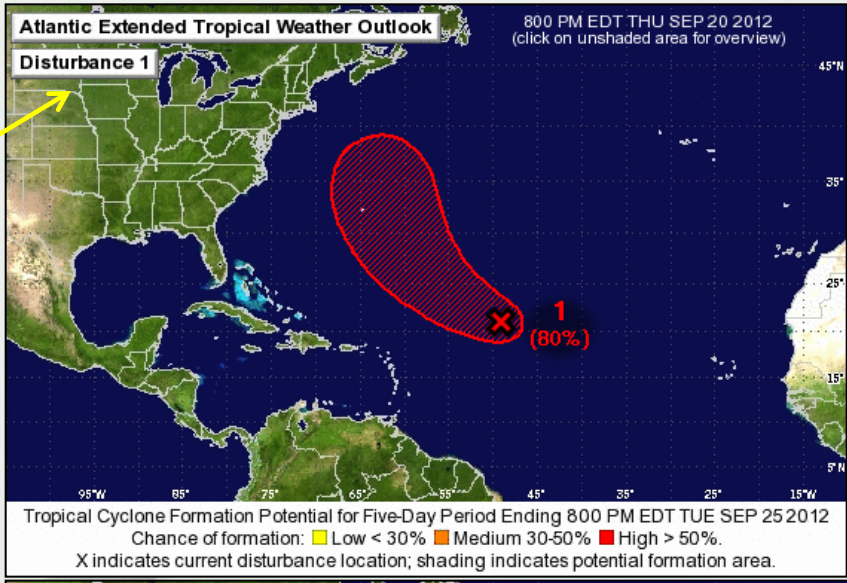
3. A TROUGH OF LOW PRESSURE COULD FORM OVER THE EXTREME SOUTHWESTERN GULF OF MEXICO AND BAY OF CAMPECHE IN A FEW DAYS...AND SOME DEVELOPMENT OF THIS SYSTEM IS POSSIBLE LATER THIS WEEK. THIS SYSTEM HAS A LOW CHANCE...NEAR 0 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS...AND A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

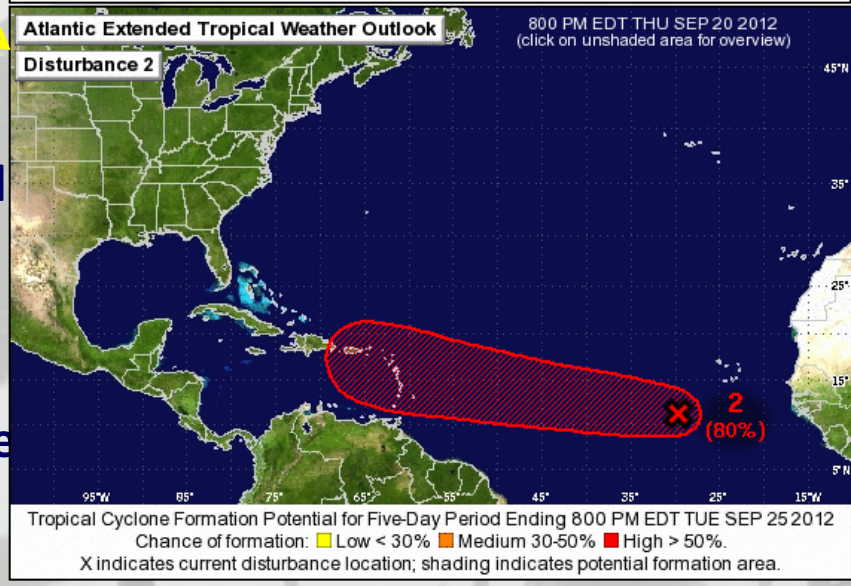
FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2013. COMMENTS ON THE EXPERIMENTAL FORECASTS CAN BE PROVIDED AT...

- 5-Day probability will always be the same or higher than the 2-day
- Since the probabilities are additive, can back out the 3-5 day %

5-Day Graphical Tropical Weather Outlook



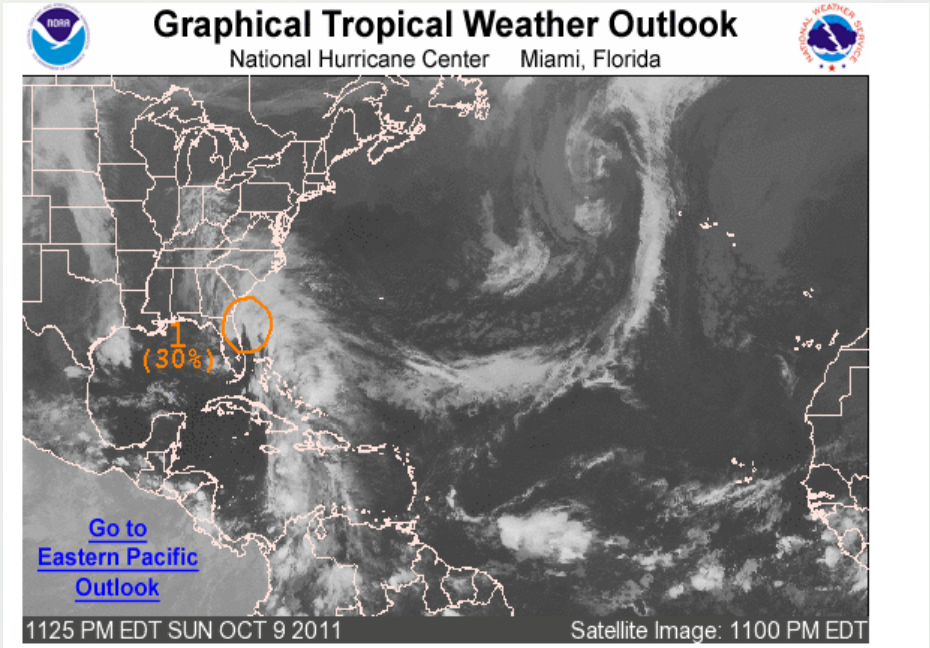




- Overview graphic shows entire basin, with single disturbance graphics available to avoid cases of overlapping areas
- (X) indicates initial location of disturbance, if exists at the issuance time
- Arrows connect initial position of disturbance with area of formation potential

Special Tropical Weather Outlook

- Issued anytime that there are significant changes with respect to disturbances in the regular Tropical Weather Outlook.
- Can be updated for either the 2- or 5-day probabilities
- Most commonly updated when formation probabilities are too low
- Often used to report findings of a recon invest mission

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ZCZC MIATWOAT ALL
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SPECIAL TROPICAL WEATHER OUTLOOK
NWS NATIONAL HURRICANE CENTER MIAMI FL
1125 PM EDT SUN OCT 9 2011

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

1. A NON-TROPICAL GALE CENTER LOCATED NEAR CAPE CANAVERAL FLORIDA IS
PRODUCING VERY STRONG WINDS ALONG THE EAST COASTS OF CENTRAL AND
NORTH FLORIDA.  CLOUDINESS AND SHOWERS ASSOCIATED WITH THIS SYSTEM
LACK SUFFICIENT ORGANIZATION TO DESIGNATE IT AS A TROPICAL OR
SUBTROPICAL CYCLONE.  THE LOW CENTER IS EXPECTED TO MOVE INLAND
OVER NORTH-CENTRAL FLORIDA BY MONDAY MORNING...AND OVER THE EXTREME
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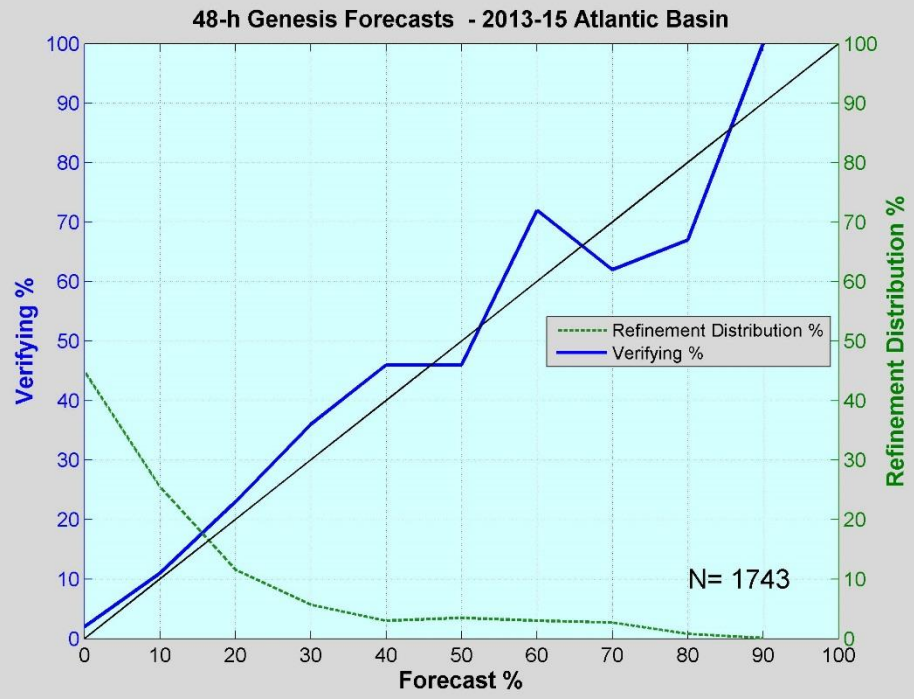
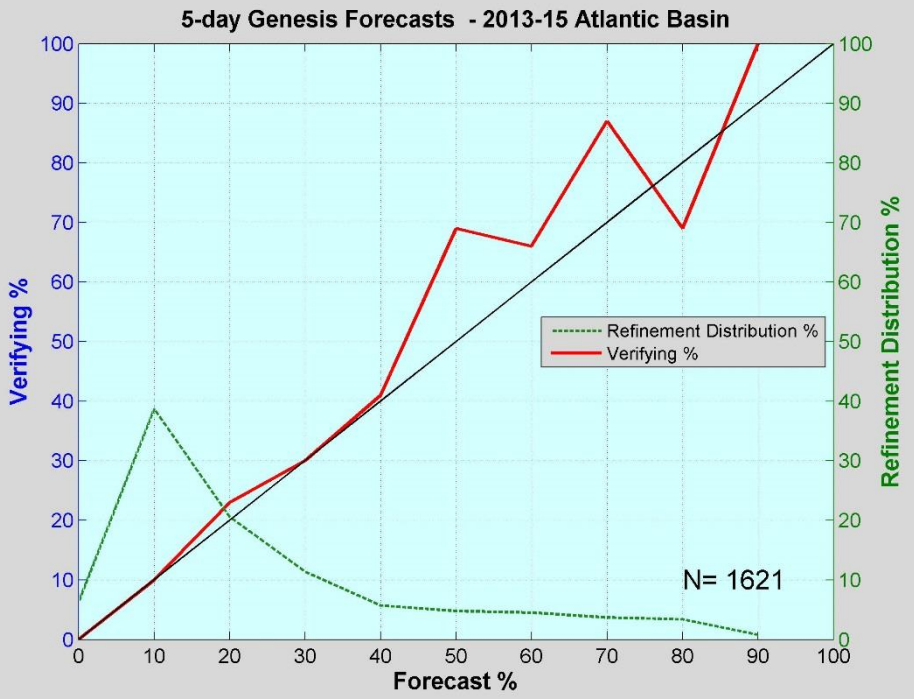
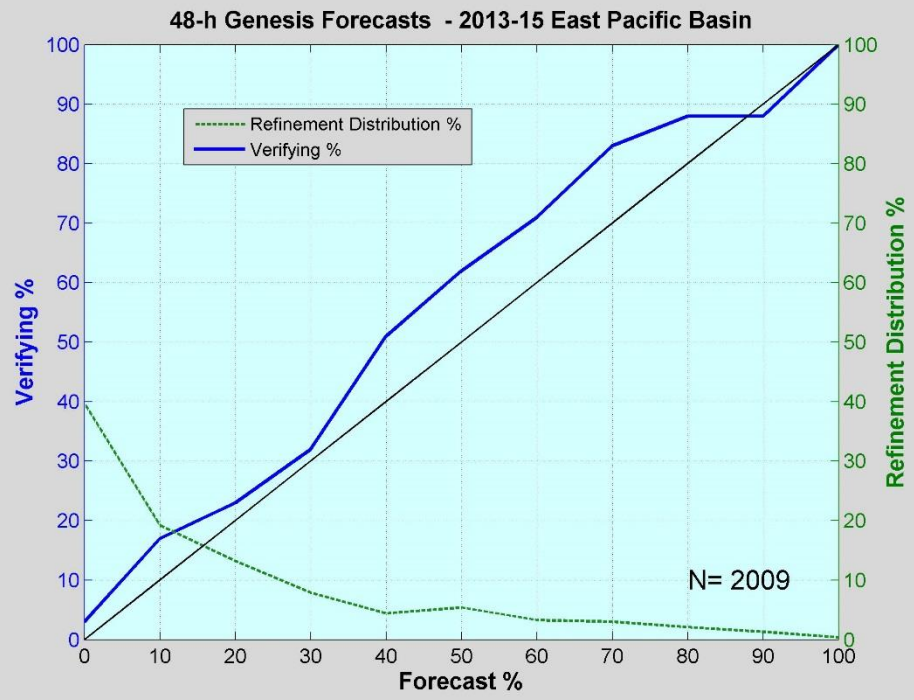
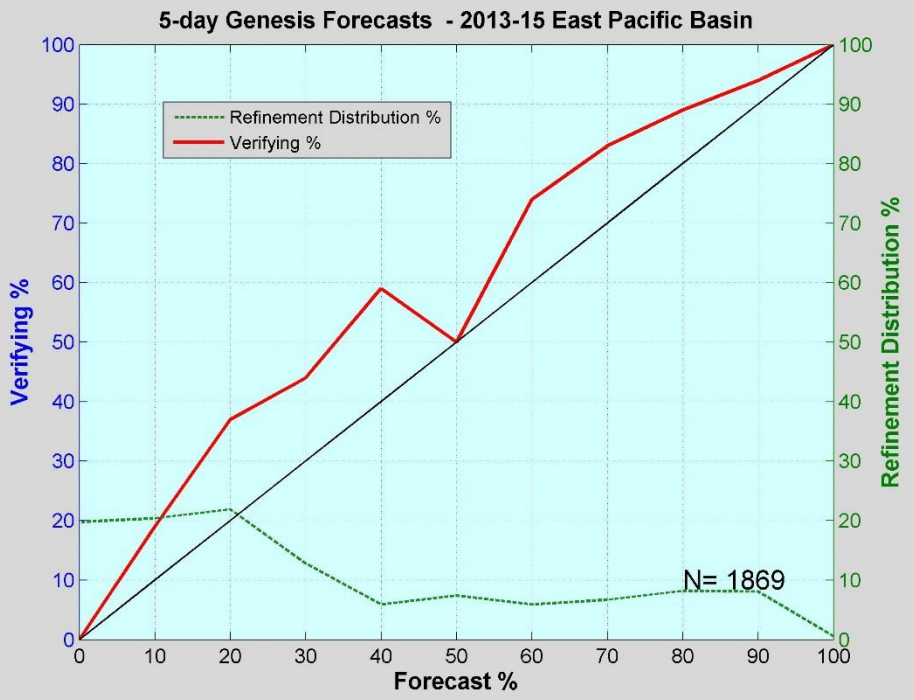
Verification Results of 2- and 5-Day Genesis Forecasts - Atlantic





Verification Results of 2- and 5-Day Genesis Forecasts - Pacific





Forecast Exercise