Assessing the predictability of the genesis of Tropical Storm Nicole (2010)

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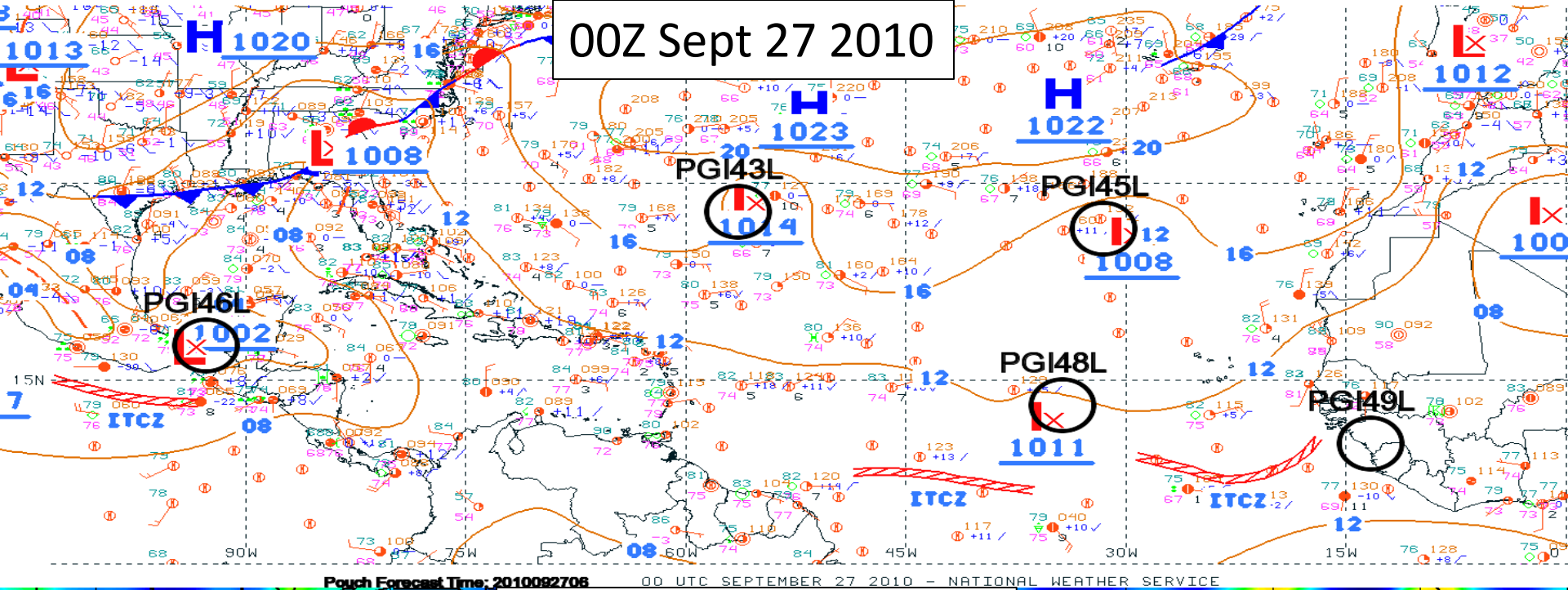
06-10-2011

Collaboration with Sharanya J. Majumdar and Ryan D. Torn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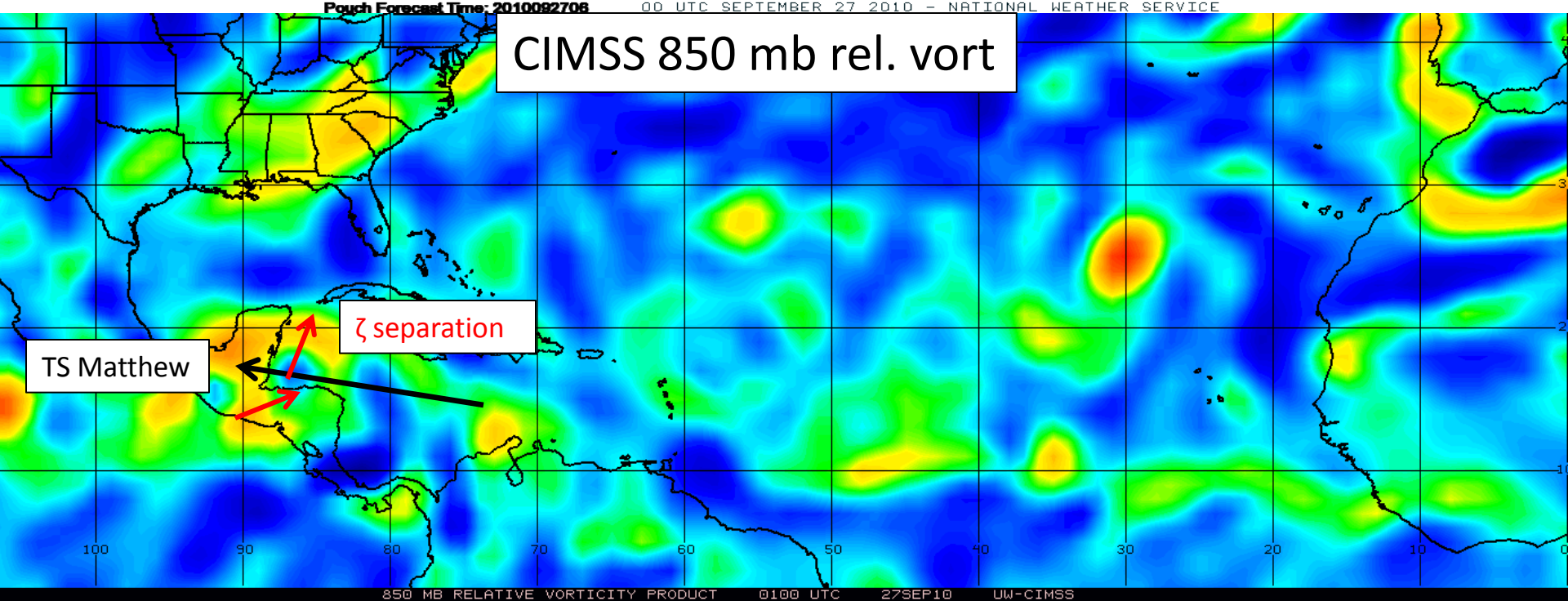
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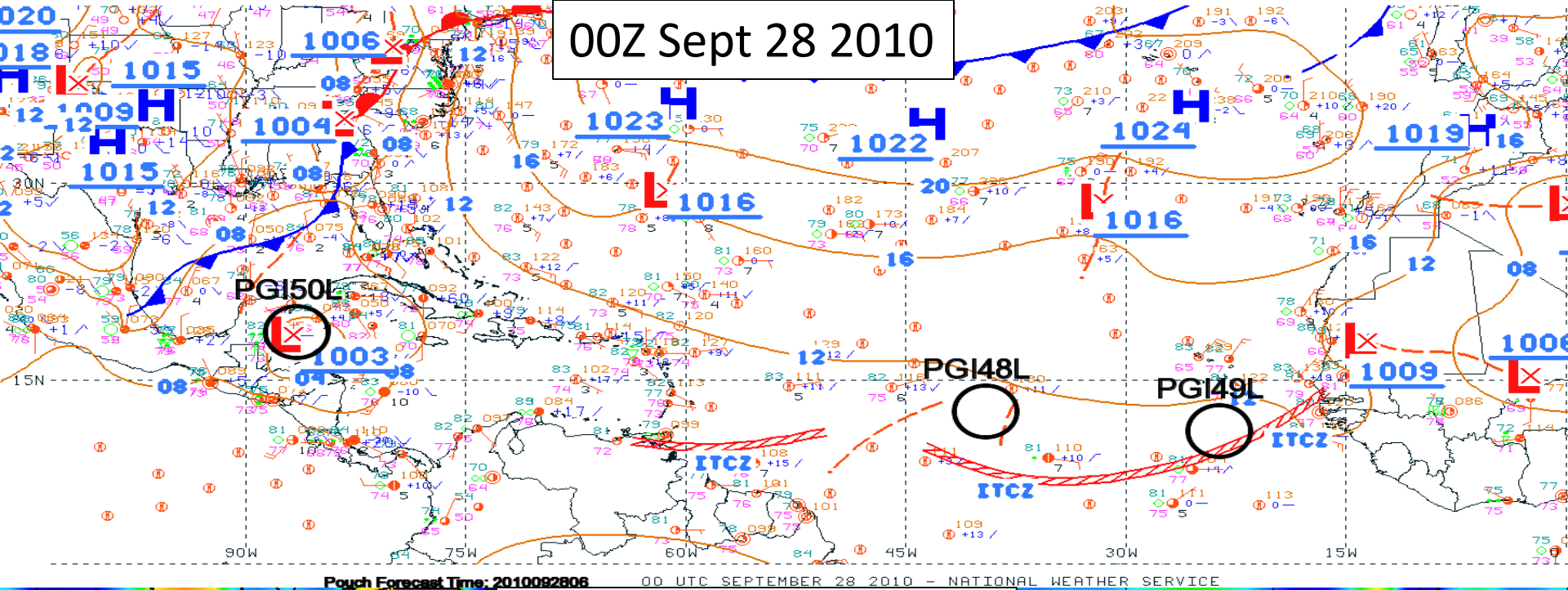
ζ separation
TS Matthew
850 MB RELATIVE VORTICITY PRODUCT 0100 UTC 27SEP10 UW-CIMSS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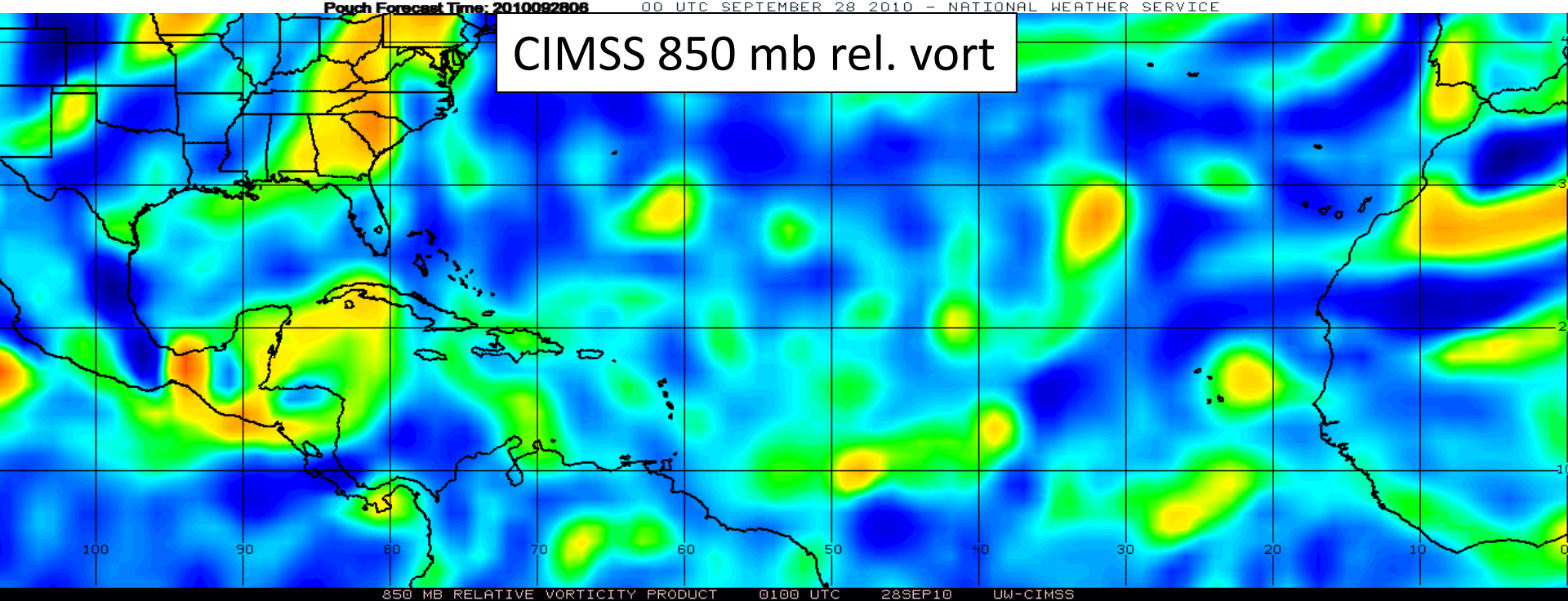
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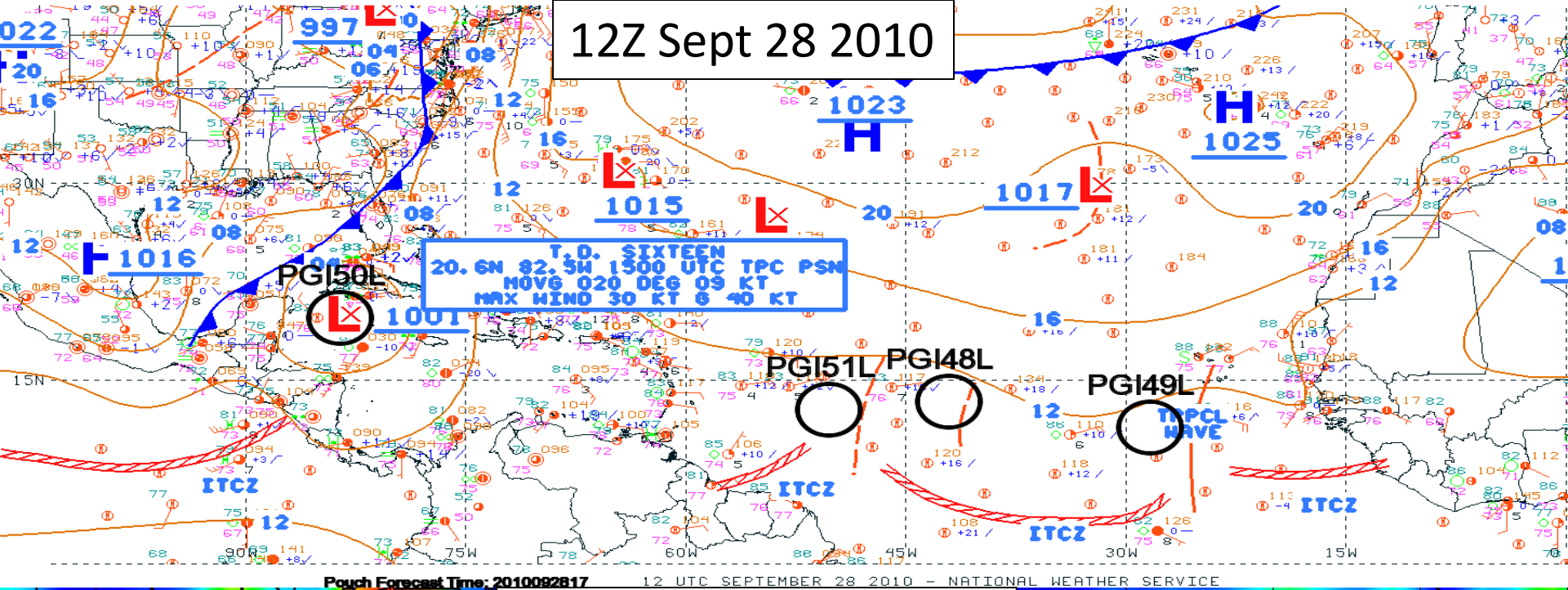
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20.6N 82.5W 1500 UTC TPC PSN
MOVG 020 DEG 09 KT
MAX WIND 30 KT G 40 KT
PGI50L
PGI51L
PGI48L
PGI49L
TROPCL WAVE
ITCZ
1016
1001
1015
1023
1025
1017
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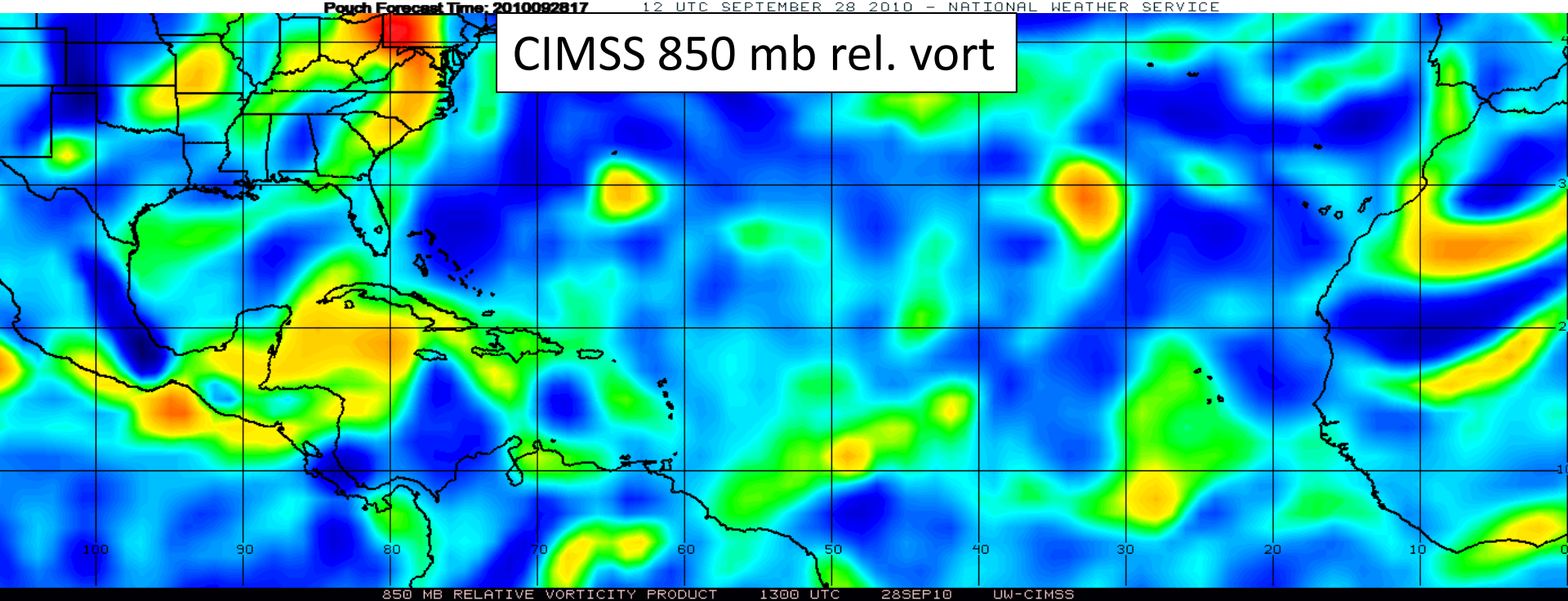
12 UTC SEPTEMBER 28 2010 - NATIONAL WEATHER SERVICE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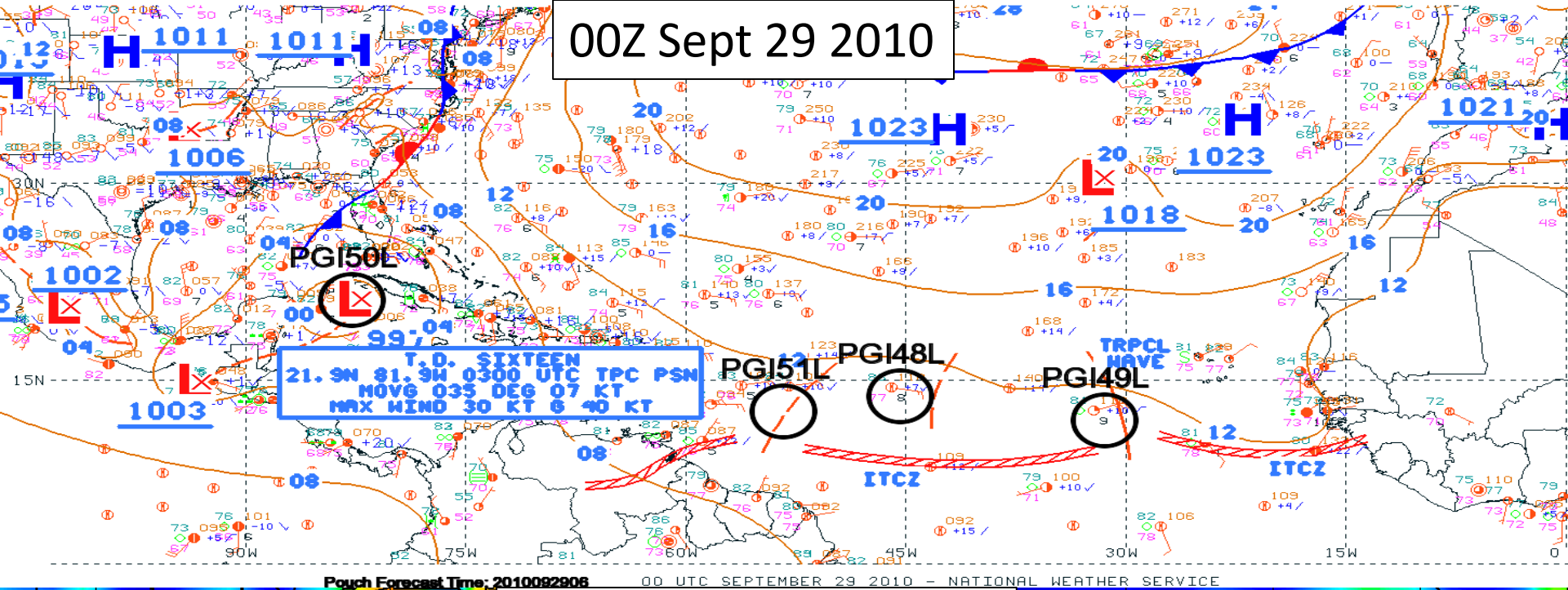
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MAX WIND 30 KT G 40 KT
TRPCL WAVE
ITCZ
ITCZ
1011
1011
1006
1002
1003
1023
1023
1018
1021
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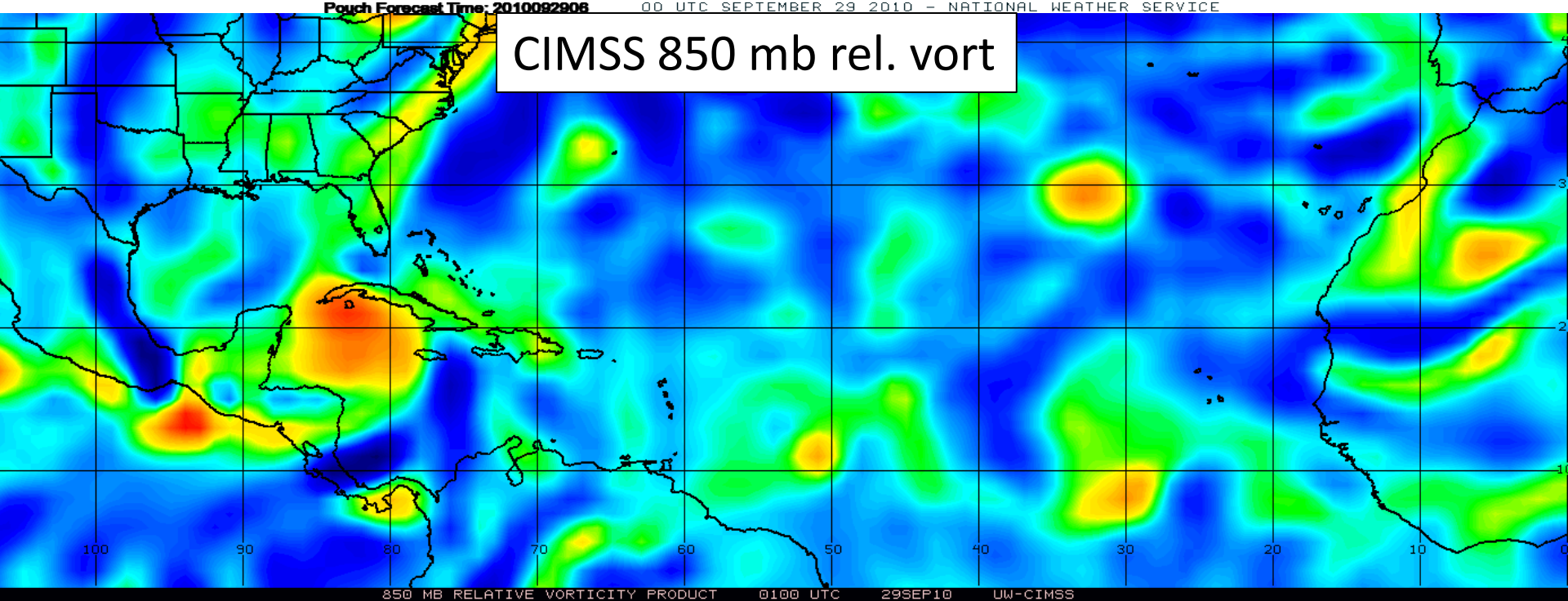
00 UTC SEPTEMBER 29 2010 - NATIONAL WEATHER SERVICE


CIMSS 850 mb rel. vort
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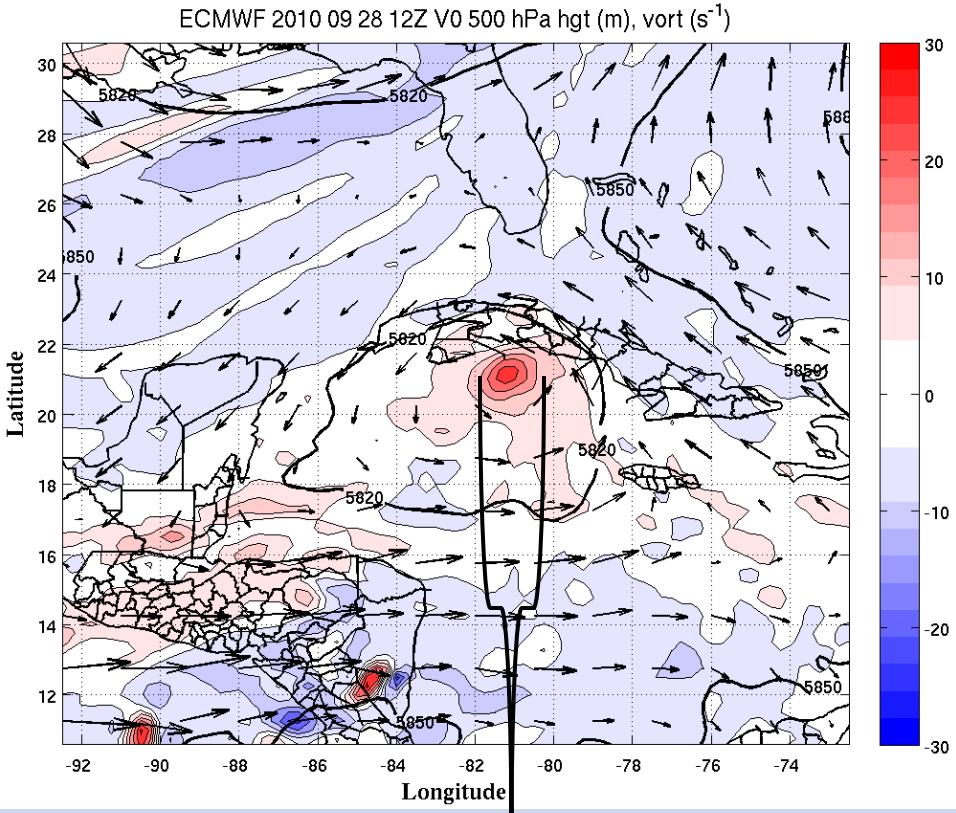
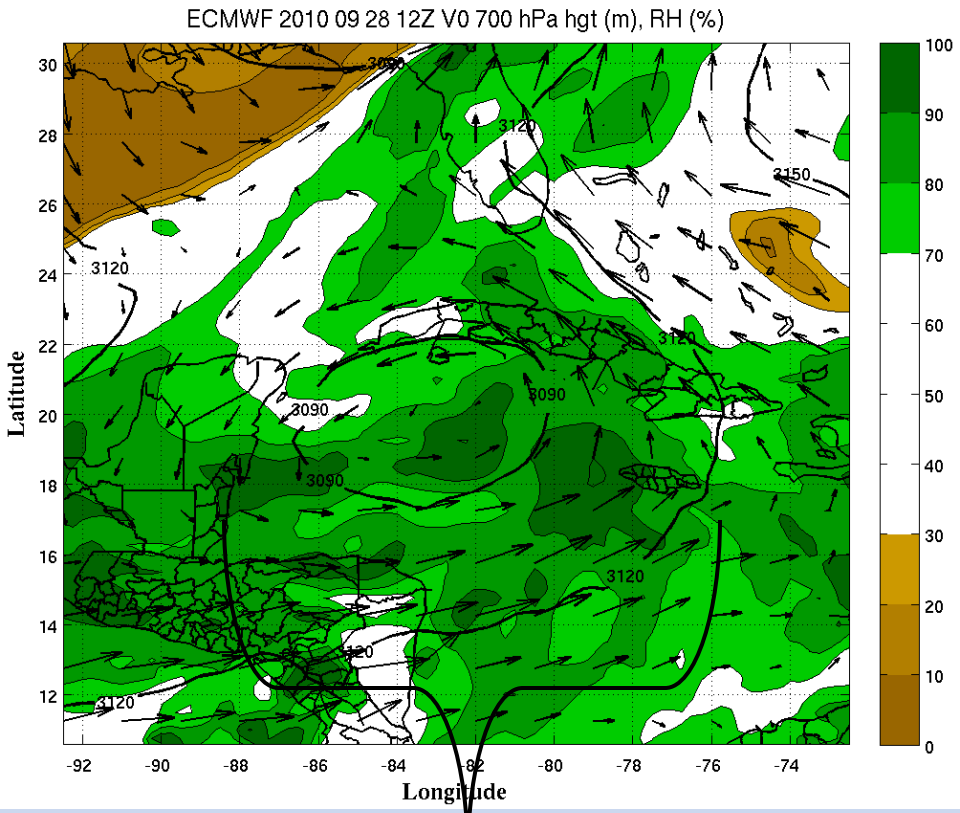
ECMWF Analysis at Time of Genesis:



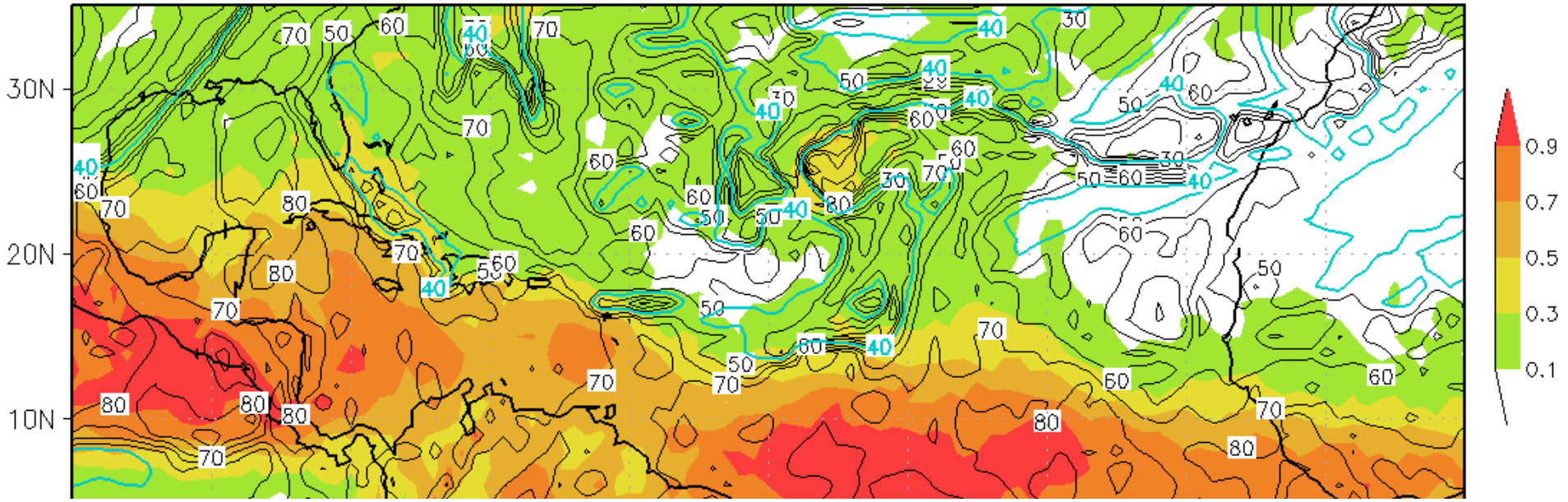


TC

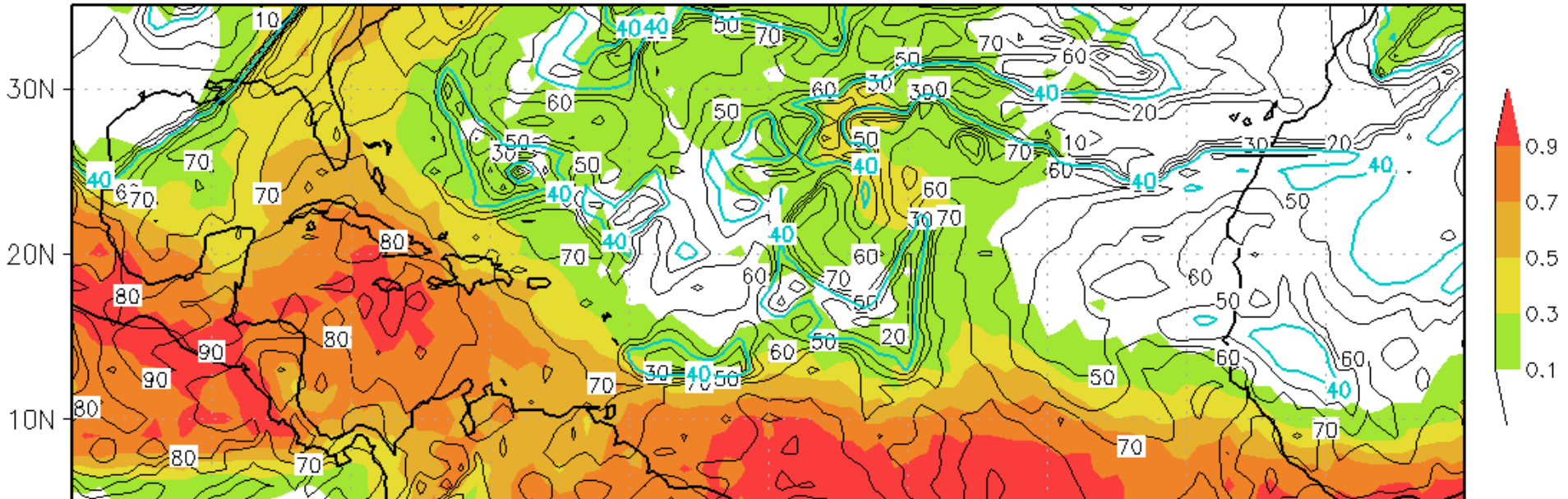
Monsoon trough

- Is the monsoon trough more predictable than the genesis of Nicole because it occurs on a larger scale?

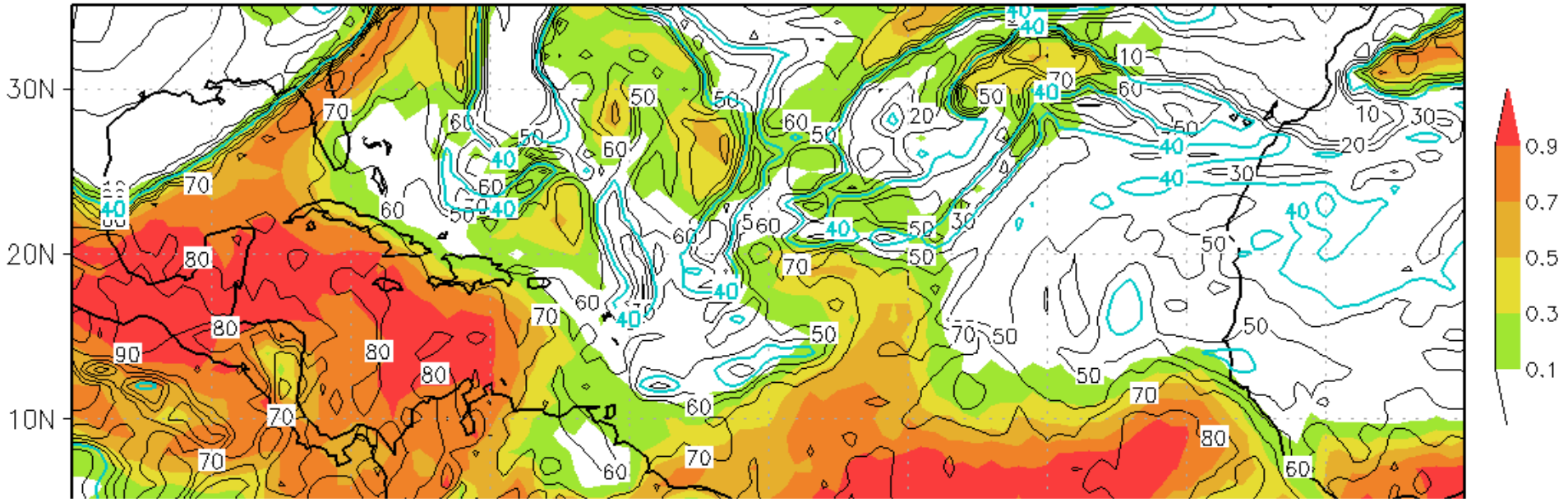
Contour: ECMWF 228-h CTRL RH at (TOP) 700 hPa and (BOT) 850 hPa. Init. 2010091900, Valid 2010092812.
Shading: TOP: Prob(700 hPa RH > 70%). BOTTOM: Prob(850 hPa RH > 85%). 50 members.



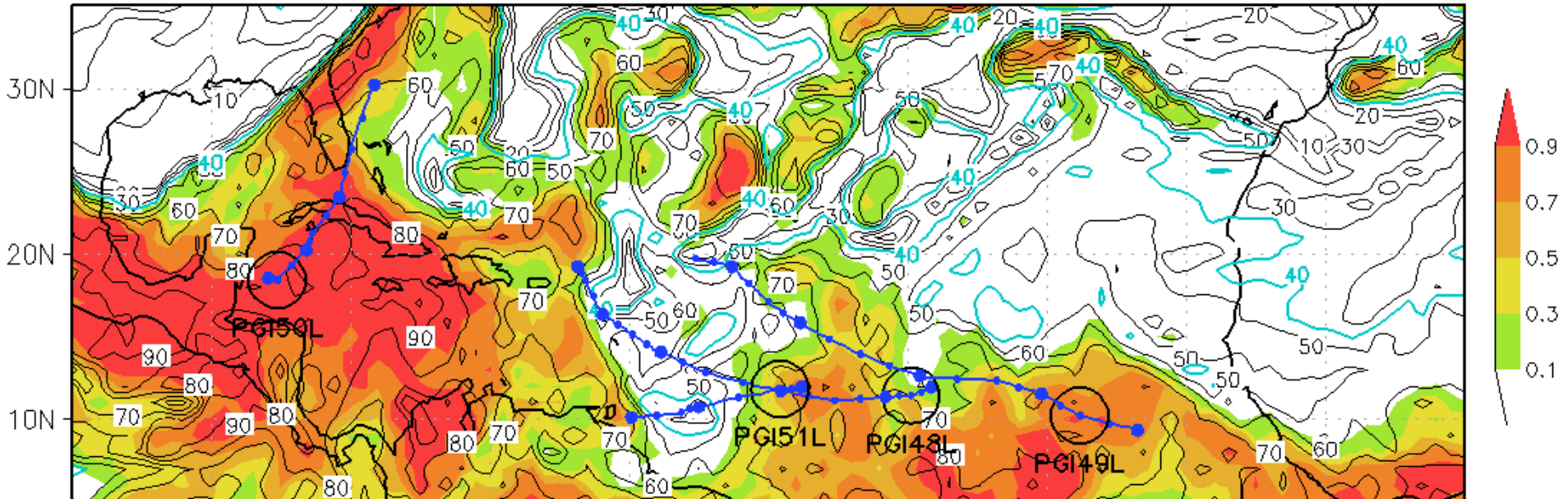
Contour: ECMWF 156-h CTRL RH at (TOP) 700 hPa and (BOT) 850 hPa. Init. 2010092200, Valid 2010092812.
Shading: TOP: Prob(700 hPa RH > 70%). BOTTOM: Prob(850 hPa RH > 85%). 50 members.



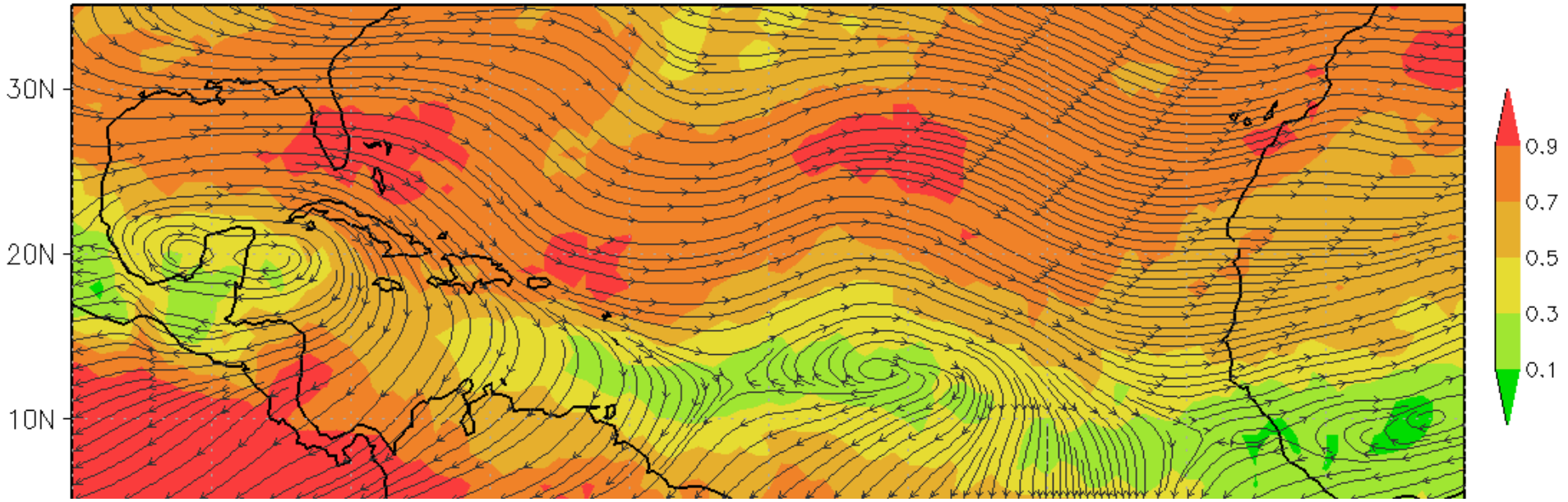
Contour: ECMWF 60-h CTRL RH at (TOP) 700 hPa and (BOT) 850 hPa. Init. 2010092600, Valid 2010092812.
Shading: TOP: Prob(700 hPa RH > 70%). BOTTOM: Prob(850 hPa RH > 85%). 50 members.



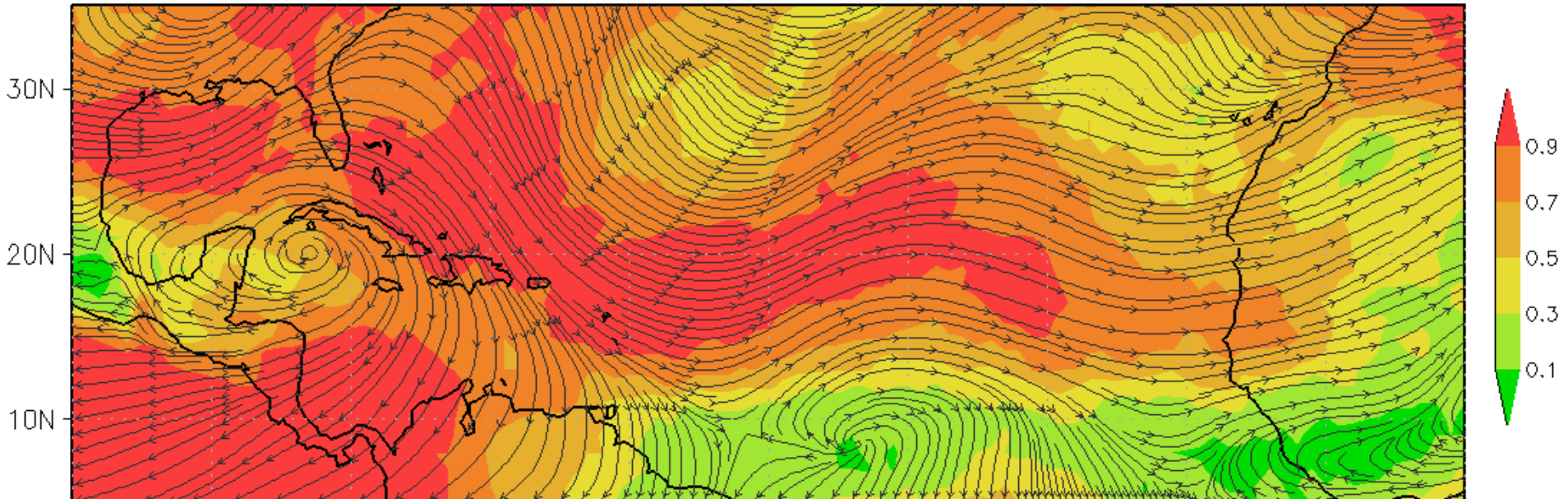
Contour: ECMWF 12-h CTRL RH at (TOP) 700 hPa and (BOT) 850 hPa. Init. 2010092800, Valid 2010092812.
Shading: TOP: Prob(700 hPa RH > 70%). BOTTOM: Prob(850 hPa RH > 85%). 50 members.



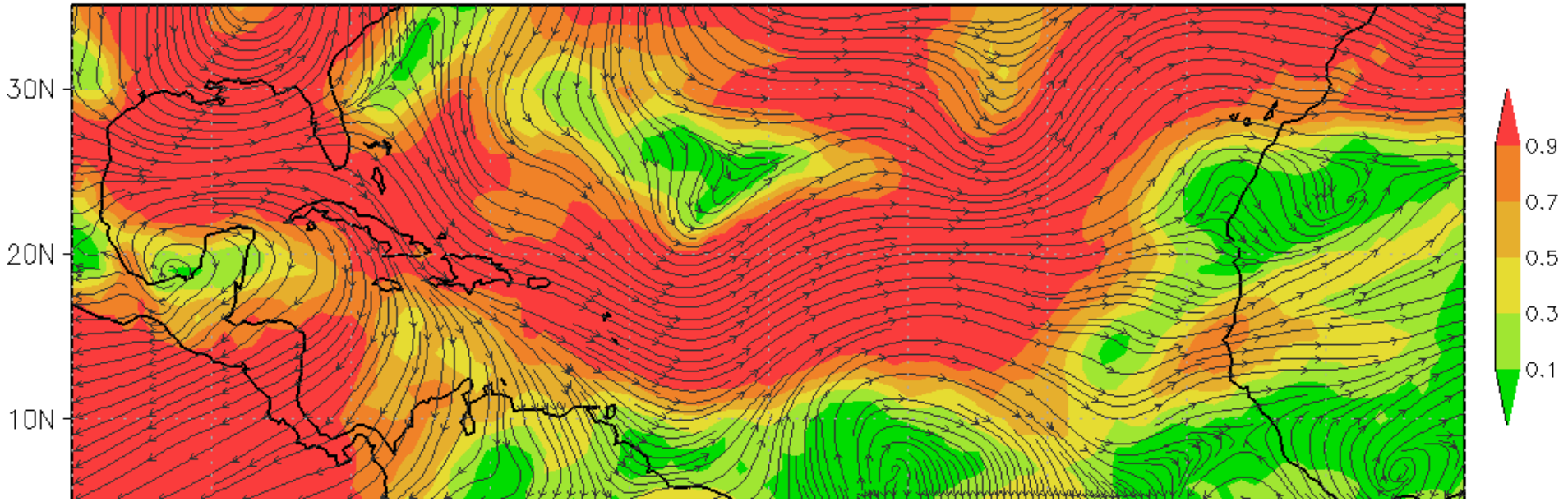
Gray: ECMWF 228-hour mean streamlines of (TOP) 200-850 and (BOTTOM) 500-850 hPa shear. 50 members.
Shading: TOP: Prob(Shear > 10 m/s). BOTTOM: Prob(Shear > 5 m/s). Init. 2010091900, Valid 2010092812.



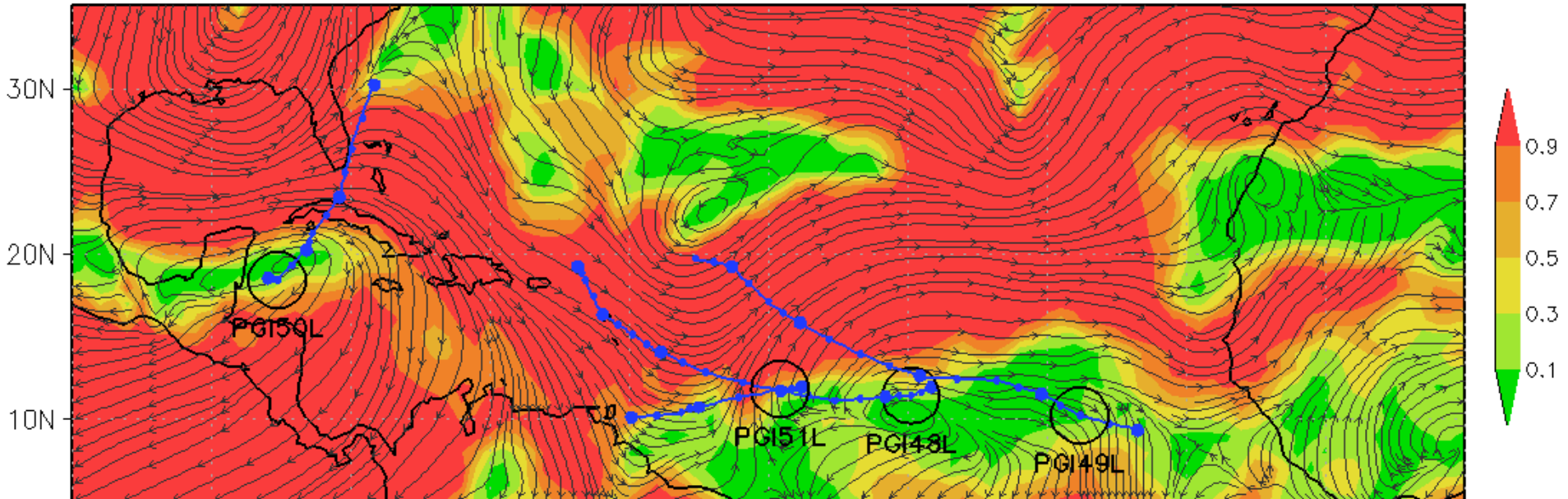
Gray: ECMWF 156-hour mean streamlines of (TOP) 200-850 and (BOTTOM) 500-850 hPa shear. 50 members.
Shading: TOP: Prob(Shear > 10 m/s). BOTTOM: Prob(Shear > 5 m/s). Init. 2010092200, Valid 2010092812.



Gray: ECMWF 60-hour mean streamlines of (TOP) 200-850 and (BOTTOM) 500-850 hPa shear. 50 members.
Shading: TOP: Prob(Shear > 10 m/s). BOTTOM: Prob(Shear > 5 m/s). Init. 2010092600, Valid 2010092812.

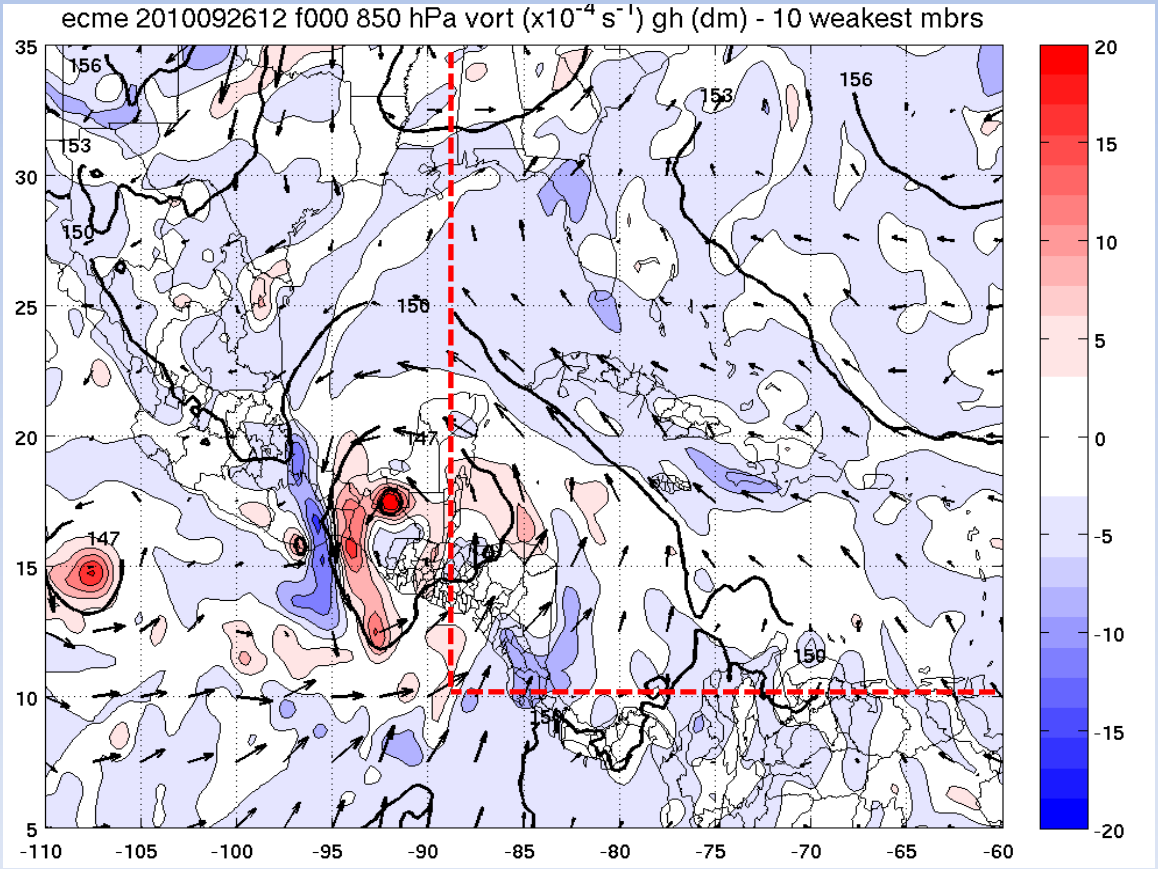


Gray: ECMWF 12-hour mean streamlines of (TOP) 200-850 and (BOTTOM) 500-850 hPa shear. 50 members.
Shading: TOP: Prob(Shear > 10 m/s). BOTTOM: Prob(Shear > 5 m/s). Init. 2010092800, Valid 2010092812.



Locations of circulation maxima

Forecasts valid at time of genesis ~ 12Z sept 28th

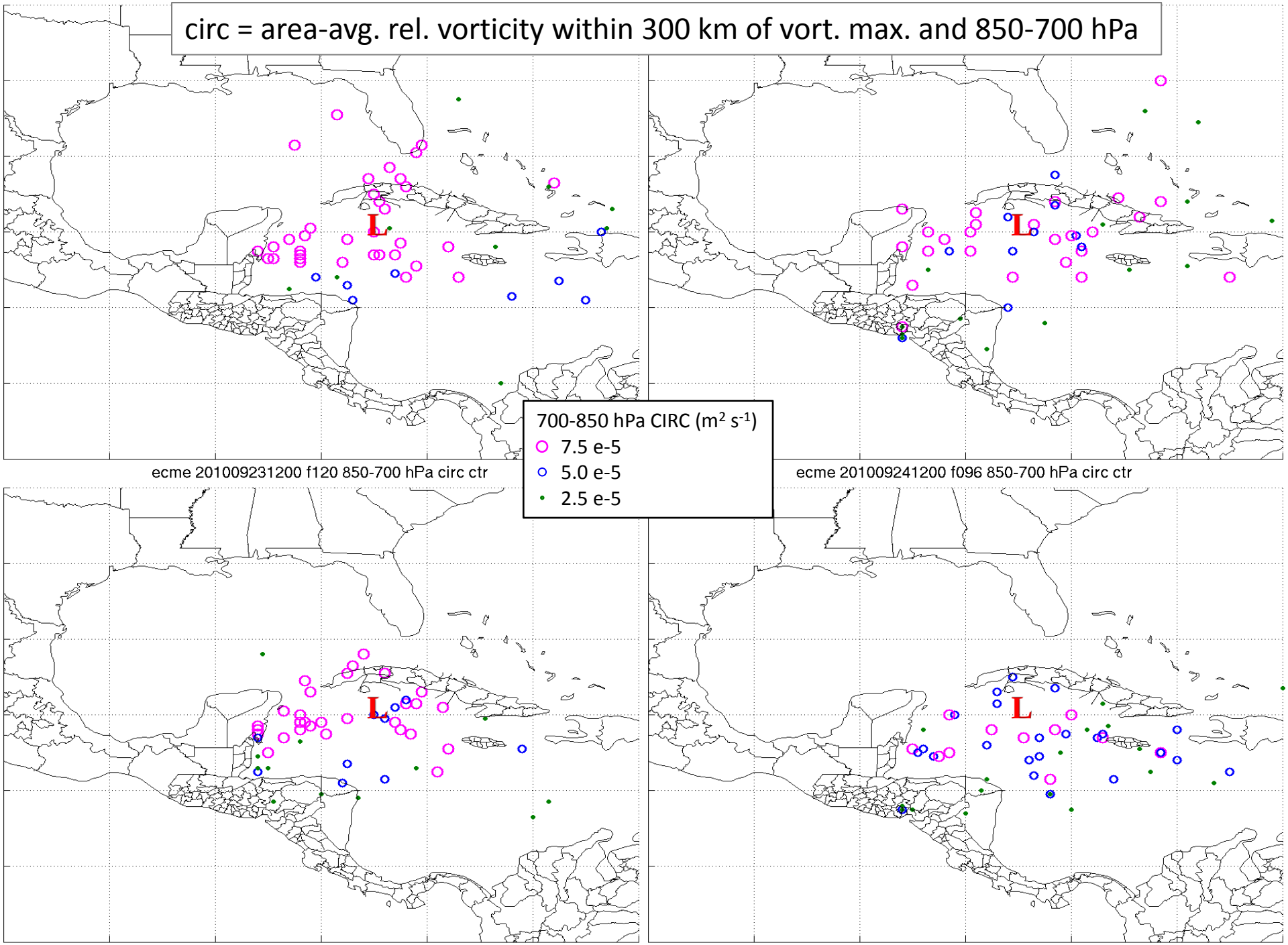


- Mask circulation west of 88 E and south of 10 N
- This acts to isolate feature over W. Carib. associated with vorticity separation, and allows us to ignore re-development of Matthew evident in a number of ensembles

ecme 201009211200 f168 850-700 hPa circ ctr

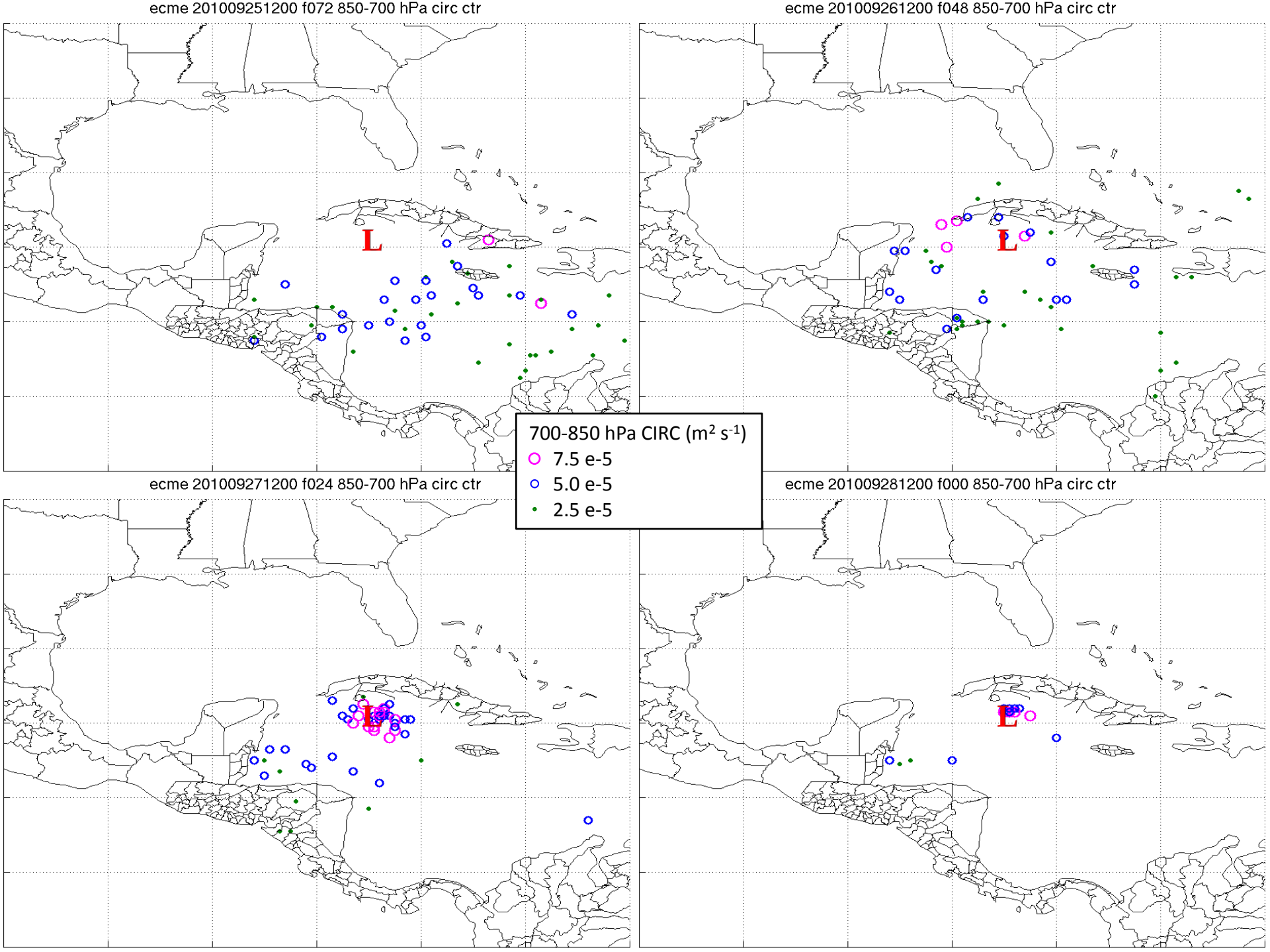
ecme 201009221200 f144 850-700 hPa circ ctr

circ = area-avg. rel. vorticity within 300 km of vort. max. and 850-700 hPa

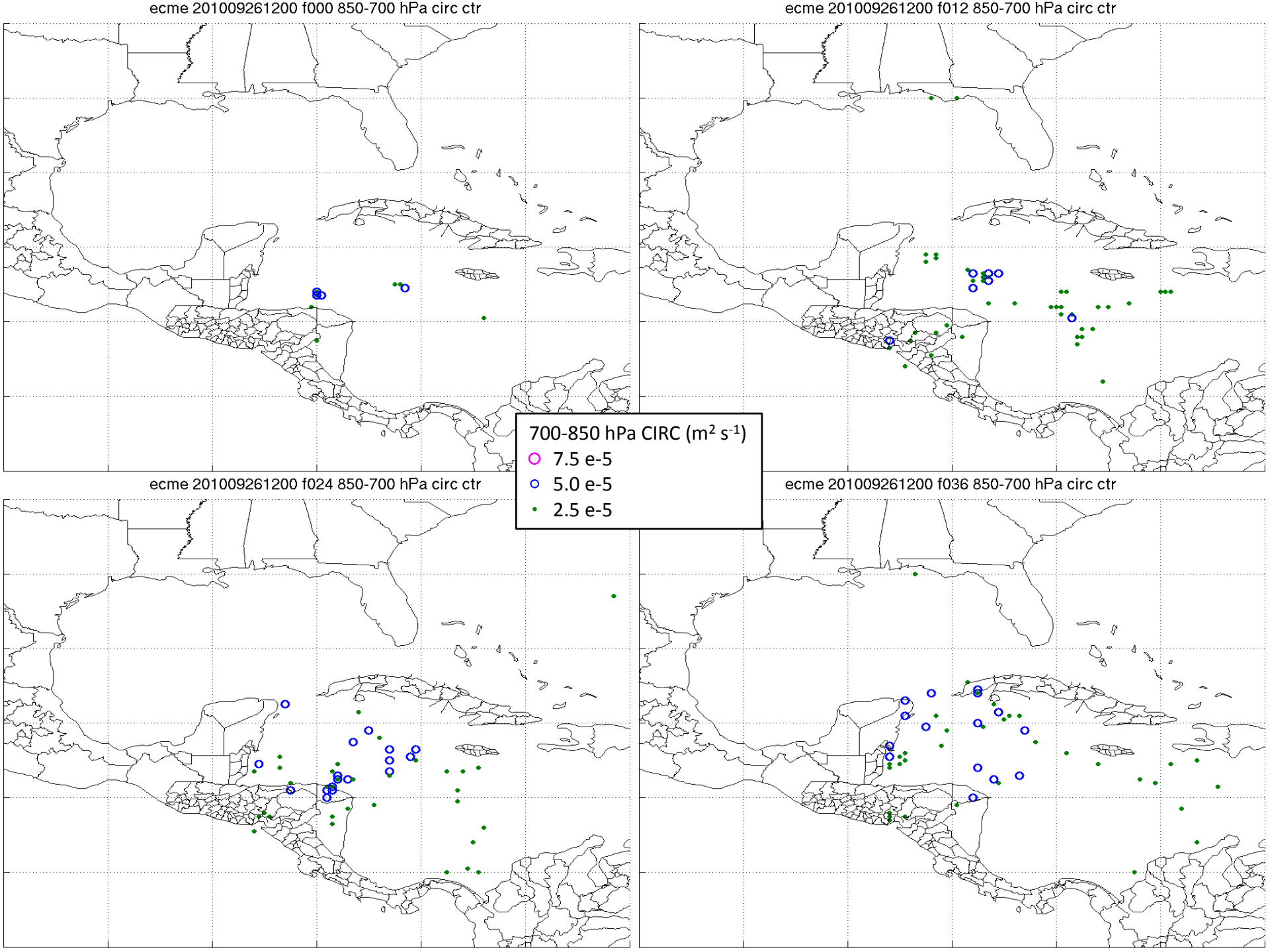


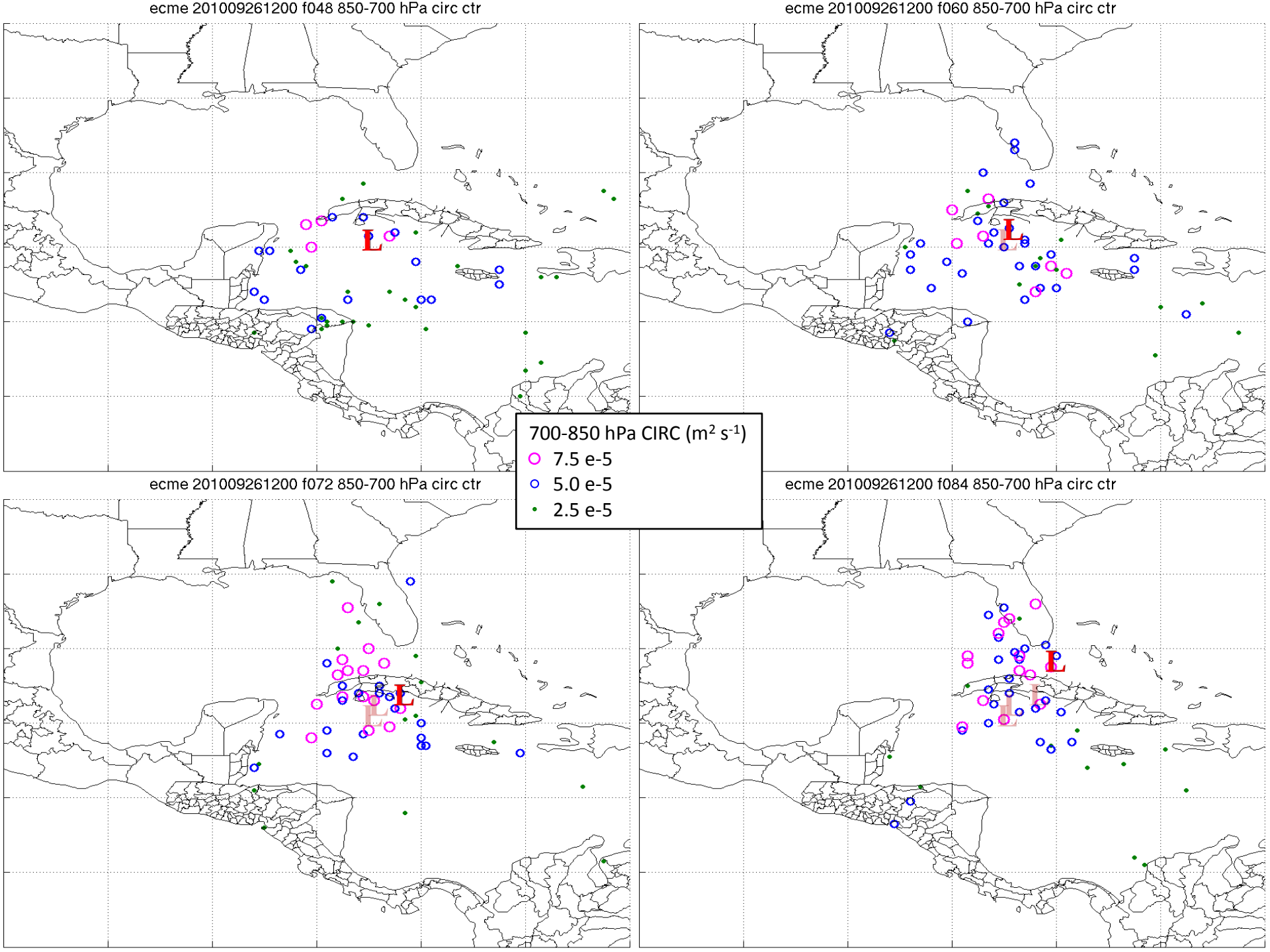
ecme 201009231200 f120 850-700 hPa circ ctr

ecme 201009241200 f096 850-700 hPa circ ctr

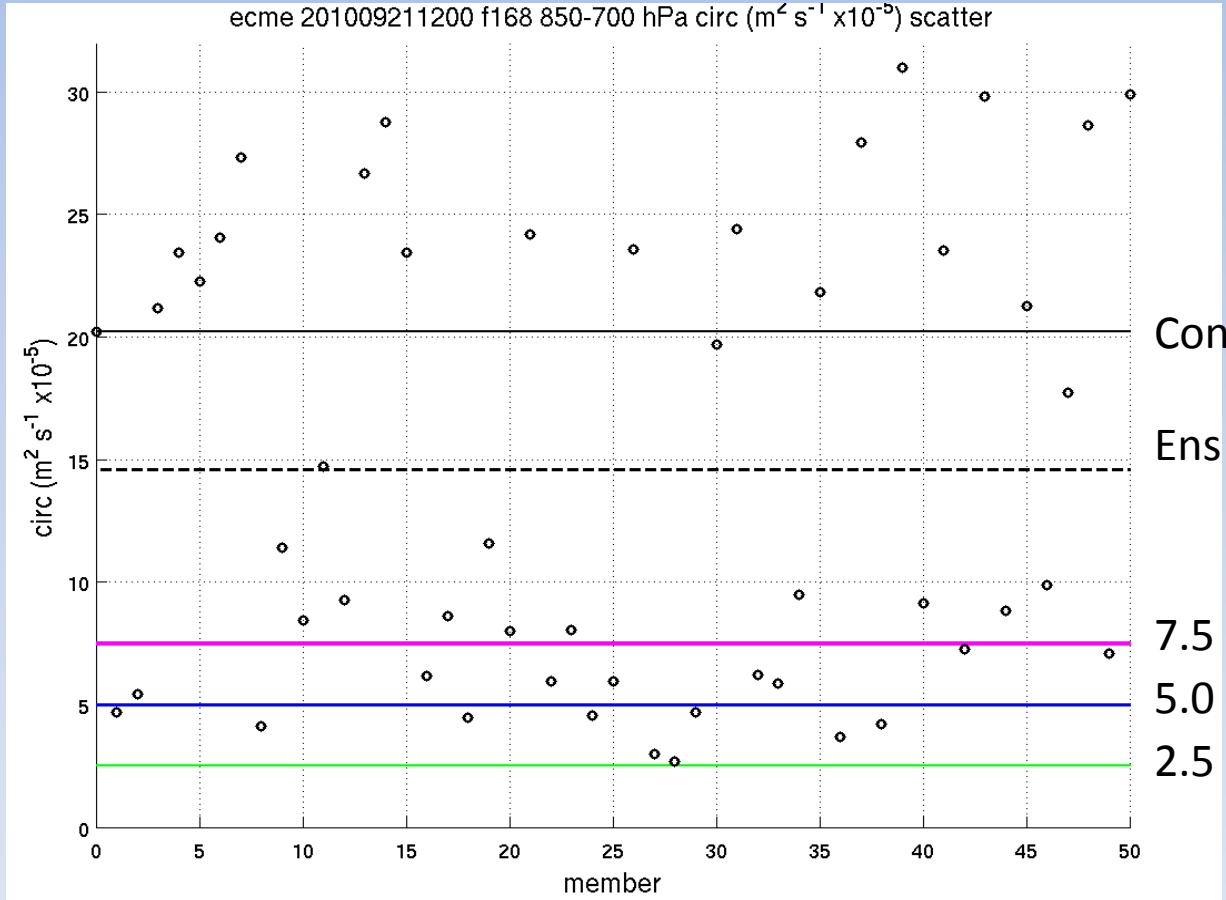

ecme 201009251200 f072 850-700 hPa circ ctr
ecme 201009261200 f048 850-700 hPa circ ctr
ecme 201009271200 f024 850-700 hPa circ ctr
ecme 201009281200 f000 850-700 hPa circ ctr
L
700-850 hPa CIRC (m² s⁻¹)
7.5 e-5
5.0 e-5
2.5 e-5

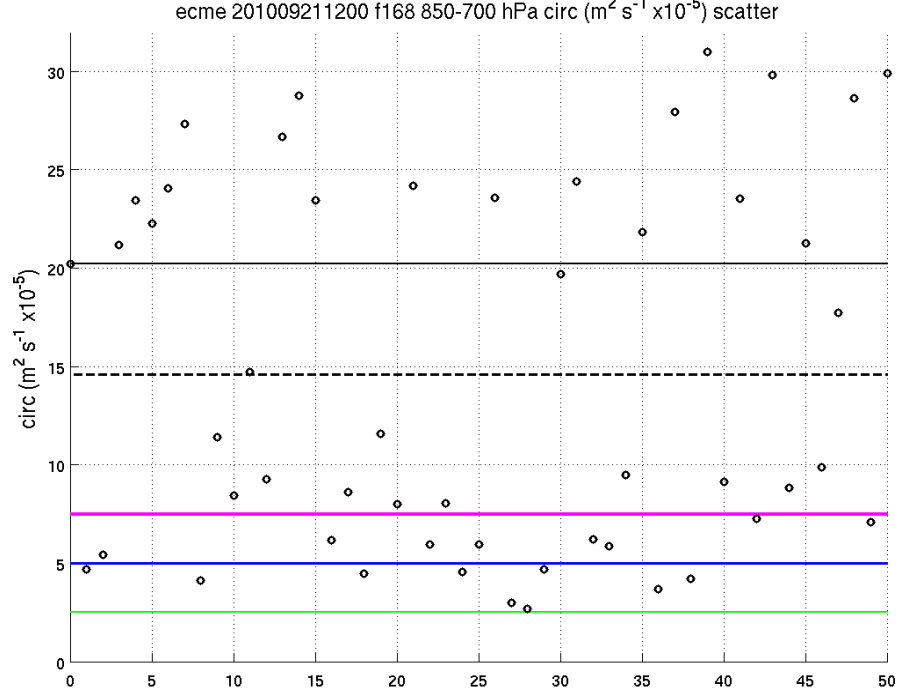
Forecast initialized 12Z 26th
(48 h pre-genesis)


ecme 201009261200 f000 850-700 hPa circ ctr
ecme 201009261200 f012 850-700 hPa circ ctr
700-850 hPa CIRC (m² s⁻¹)
7.5 e-5
5.0 e-5
2.5 e-5
ecme 201009261200 f024 850-700 hPa circ ctr
ecme 201009261200 f036 850-700 hPa circ ctr


ecme 201009261200 f048 850-700 hPa circ ctr
ecme 201009261200 f060 850-700 hPa circ ctr
ecme 201009261200 f072 850-700 hPa circ ctr
ecme 201009261200 f084 850-700 hPa circ ctr
700-850 hPa CIRC (m² s⁻¹)
7.5 e-5
5.0 e-5
2.5 e-5
L

Forecasts valid at time of genesis ~ 12Z sept 28th

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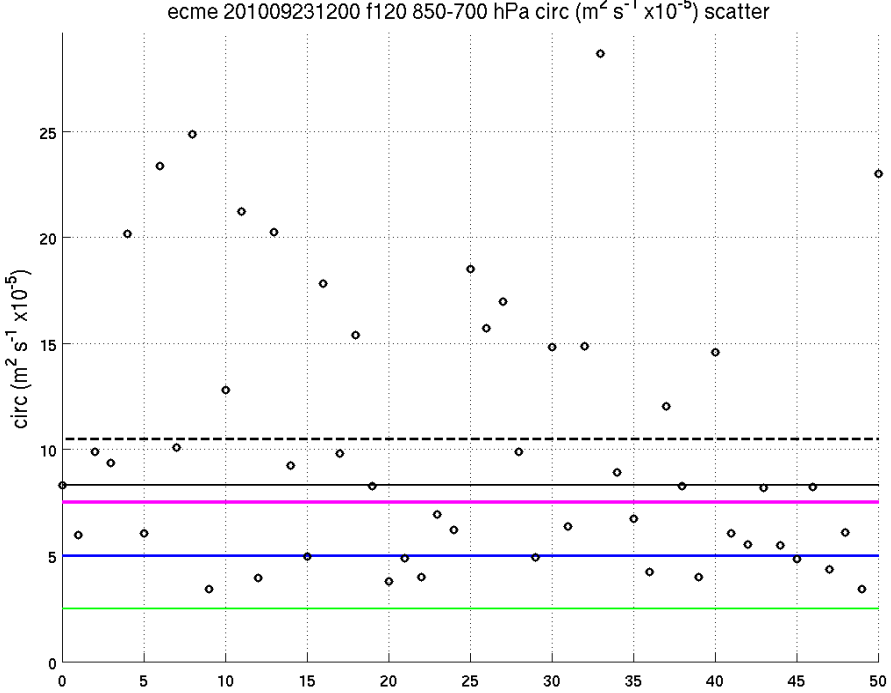
circ (m2 s-1 x10-5)
member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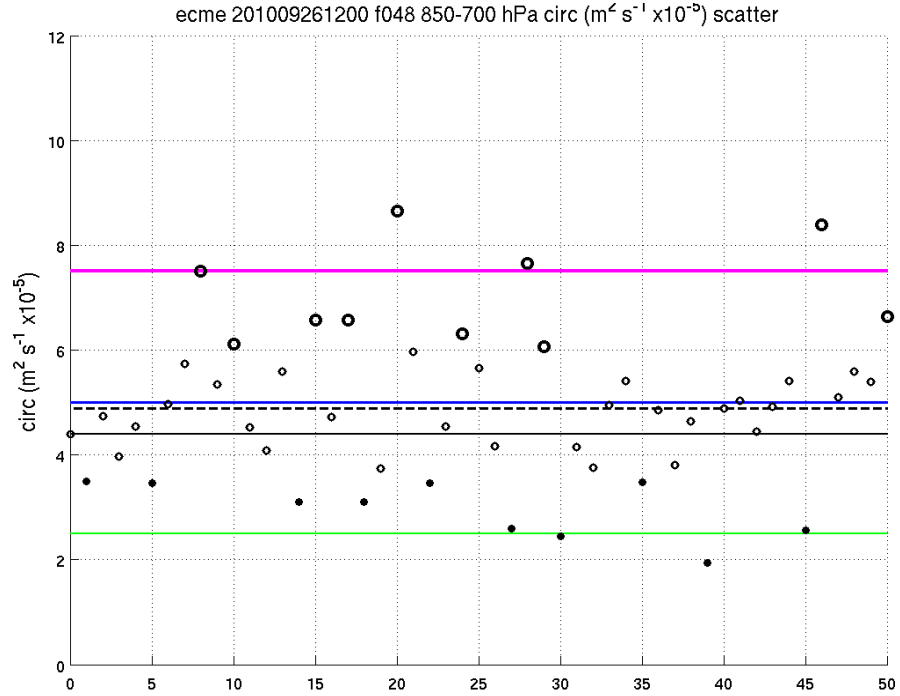
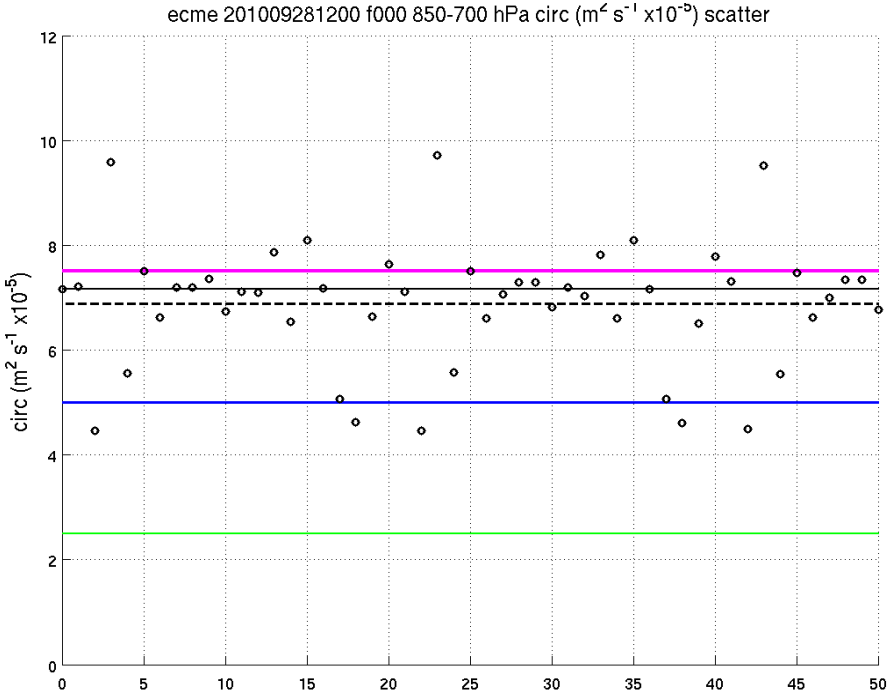
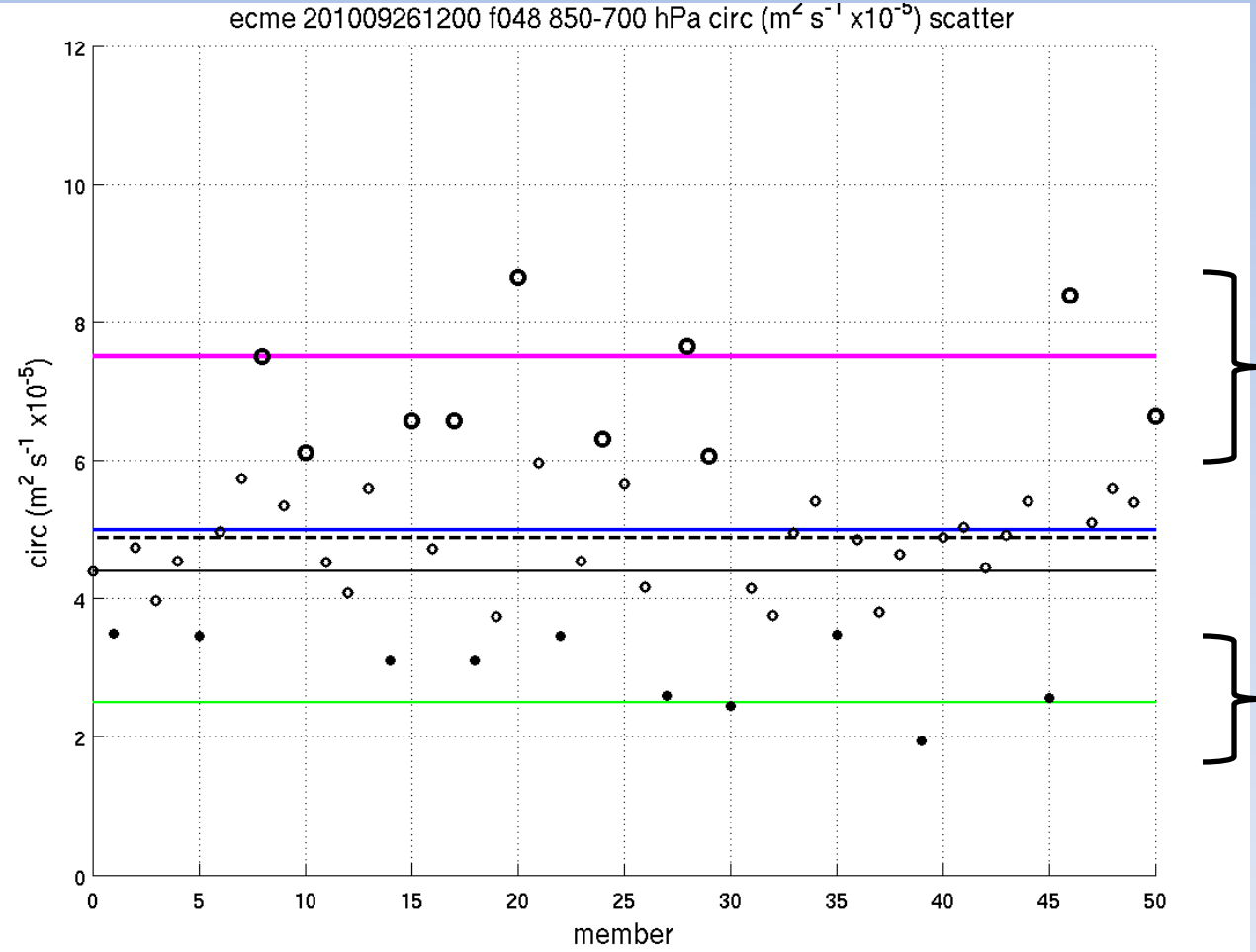
circ (m2 s-1 x10-5)
member


ecme 201009261200 f048 850-700 hPa circ (m2 s-1 x10-5) scatter
circ (m2 s-1 x10-5)
member

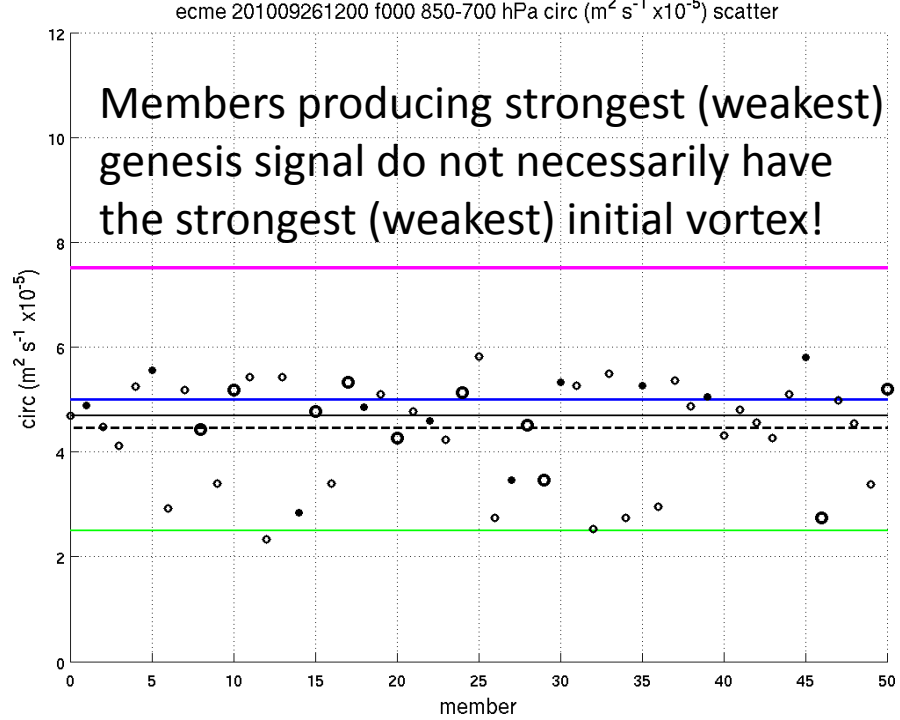

ecme 201009281200 f000 850-700 hPa circ (m2 s-1 x10-5) scatter
circ (m2 s-1 x10-5)
member

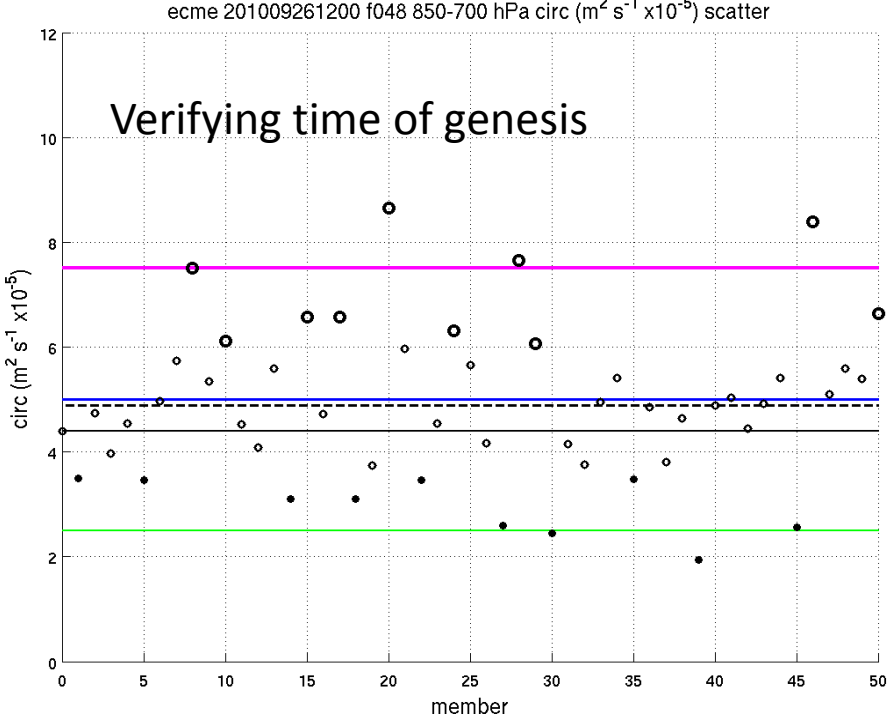
Forecast initialized 12Z 26th (48 h pre-genesis)

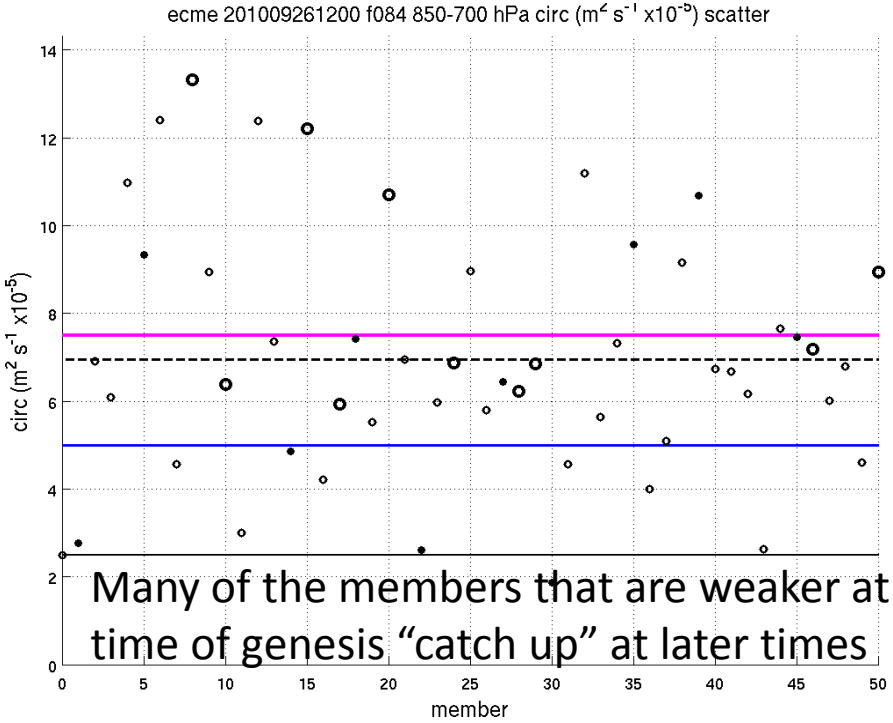


10 strongest members enlarged

10 weakest members filled


ecme 201009261200 f000 850-700 hPa circ (m2 s-1 x10-5) scatter
Members producing strongest (weakest) genesis signal do not necessarily have the strongest (weakest) initial vortex!
circ (m2 s-1 x10-5)
member

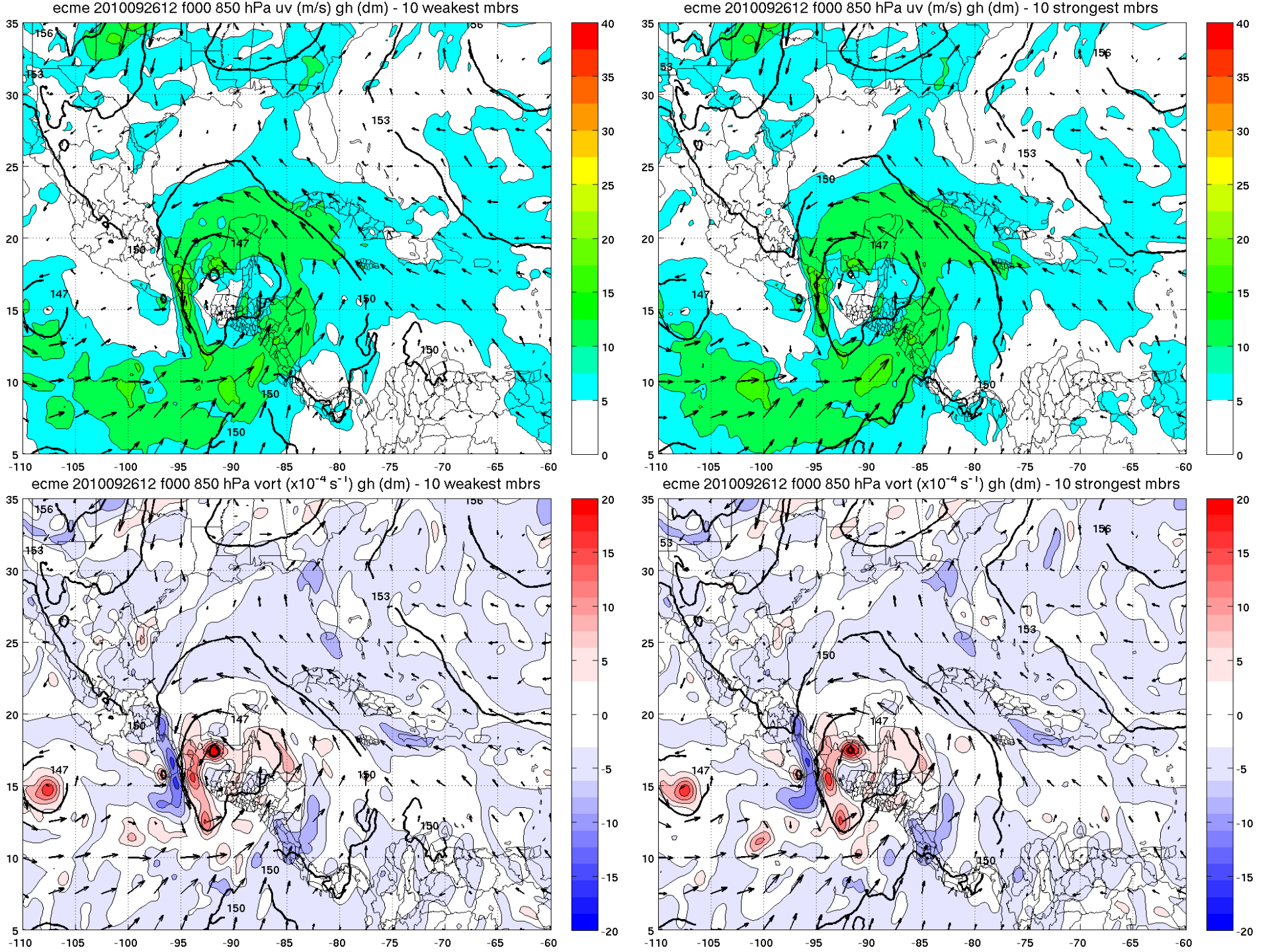

ecme 201009261200 f048 850-700 hPa circ (m2 s-1 x10-5) scatter
Verifying time of genesis
circ (m2 s-1 x10-5)
member

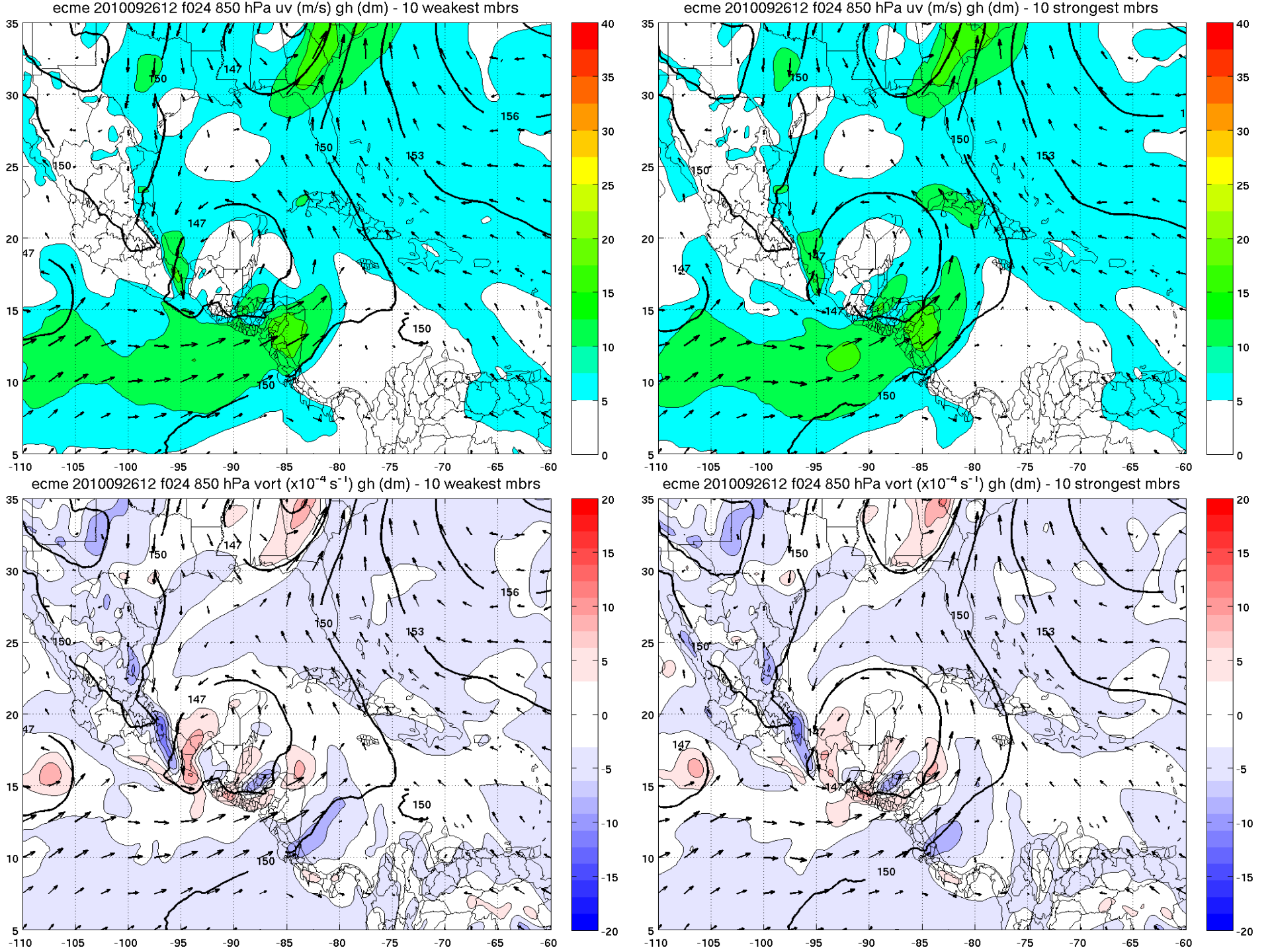

ecme 201009261200 f084 850-700 hPa circ (m2 s-1 x10-5) scatter
Many of the members that are weaker at time of genesis "catch up" at later times
circ (m2 s-1 x10-5)
member

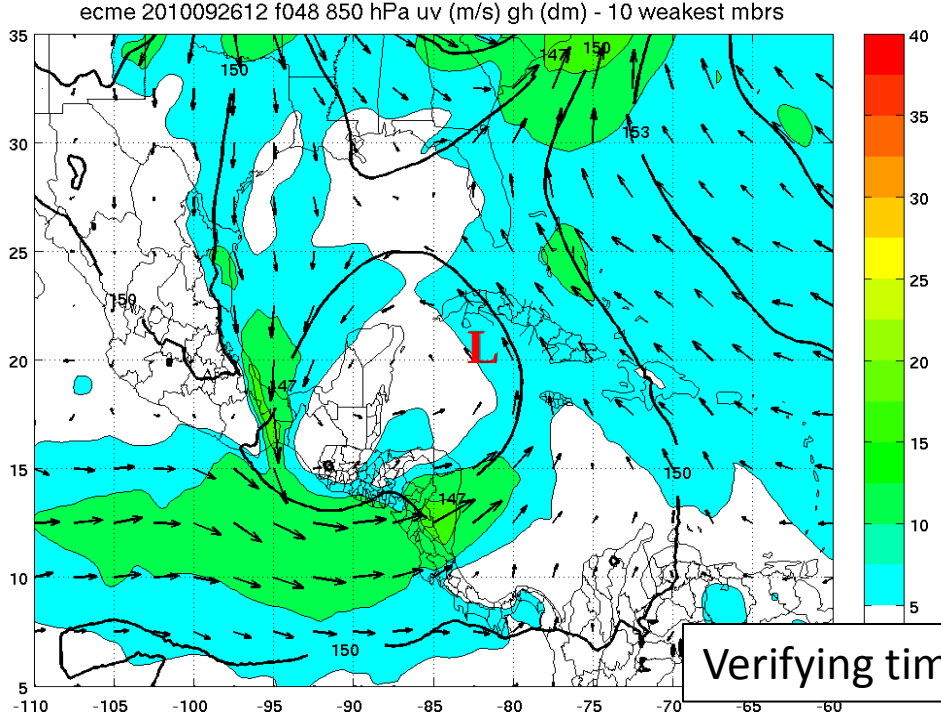
Discussion Points

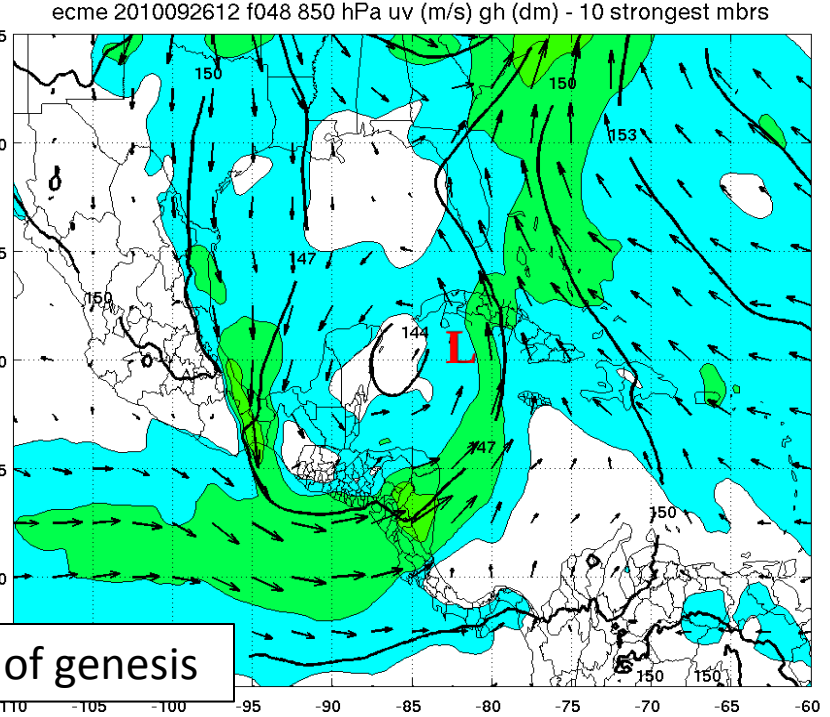
- It is possible for global models to capture genesis without "getting the small scales right"
- However, having a correct end result (a TC) does not necessarily equate to the model representing the correct processes by which genesis occurs adequately, or for the right reasons
- Tropical Storm Nicole (2010):
  - High moisture and relatively low shear associated with the monsoon trough from which Nicole was formed are very predictable out to 7+ days
  - The fact that a TC will exist somewhere within the monsoon trough also quite predictable out to 7+ days
  - The location and timing of genesis are much less predictable
  - The predictability of the mesoscale mechanisms of genesis appears to be low, but requires further investigation

Evolution of mean of 10 strongest members vs 10 weakest members
init: 12Z 09-26
valid: 12Z 09-28

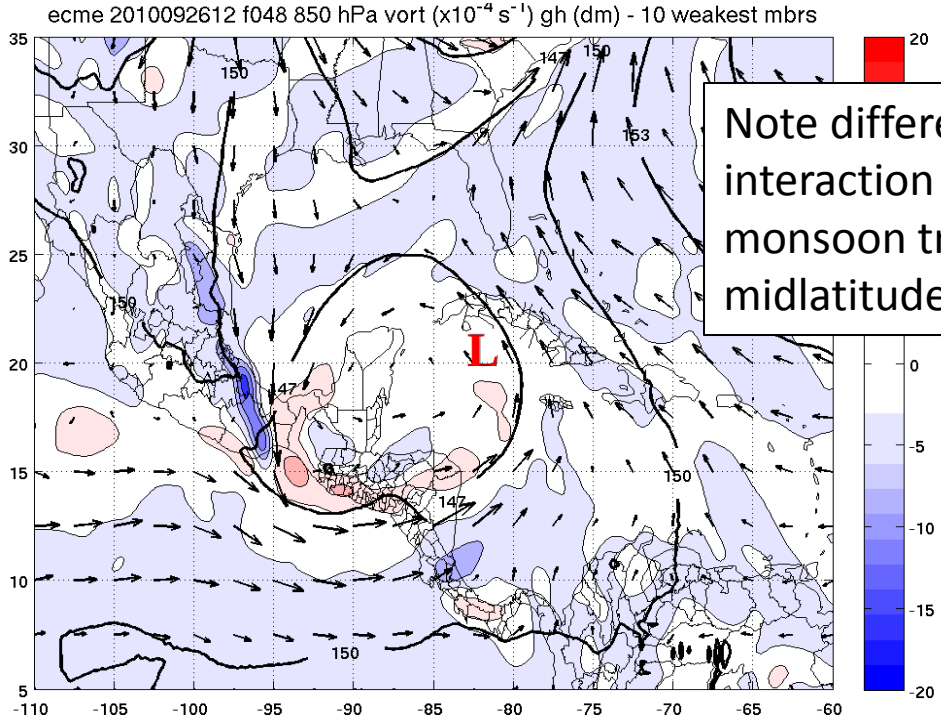

ecme 2010092612 f000 850 hPa uv (m/s) gh (dm) - 10 weakest mbrs
ecme 2010092612 f000 850 hPa uv (m/s) gh (dm) - 10 strongest mbrs
ecme 2010092612 f000 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 weakest mbrs
ecme 2010092612 f000 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 strongest mbrs

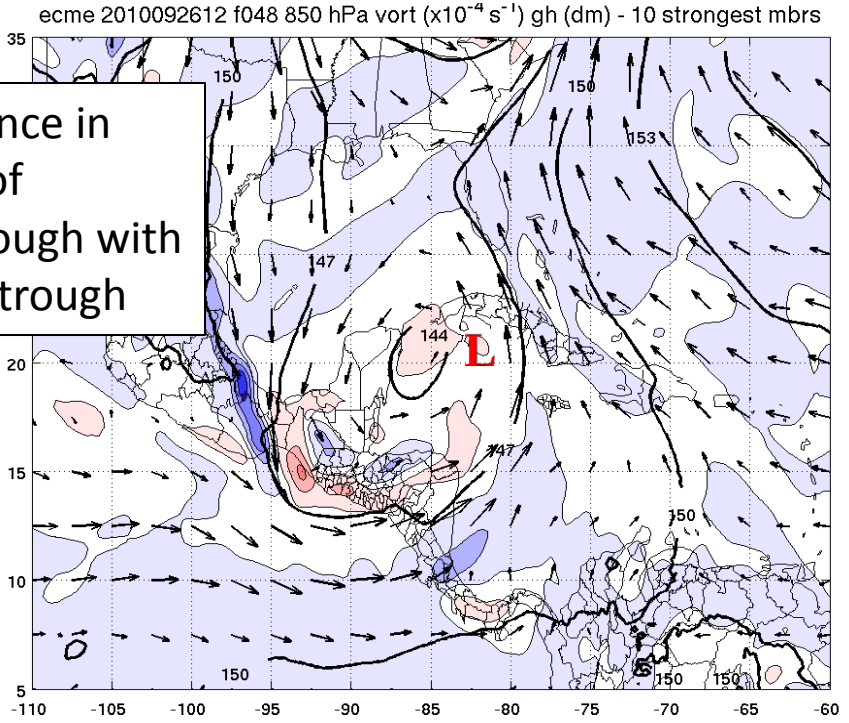

ecme 2010092612 f024 850 hPa uv (m/s) gh (dm) - 10 weakest mbrs
ecme 2010092612 f024 850 hPa uv (m/s) gh (dm) - 10 strongest mbrs
ecme 2010092612 f024 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 weakest mbrs
ecme 2010092612 f024 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 strongest mbrs



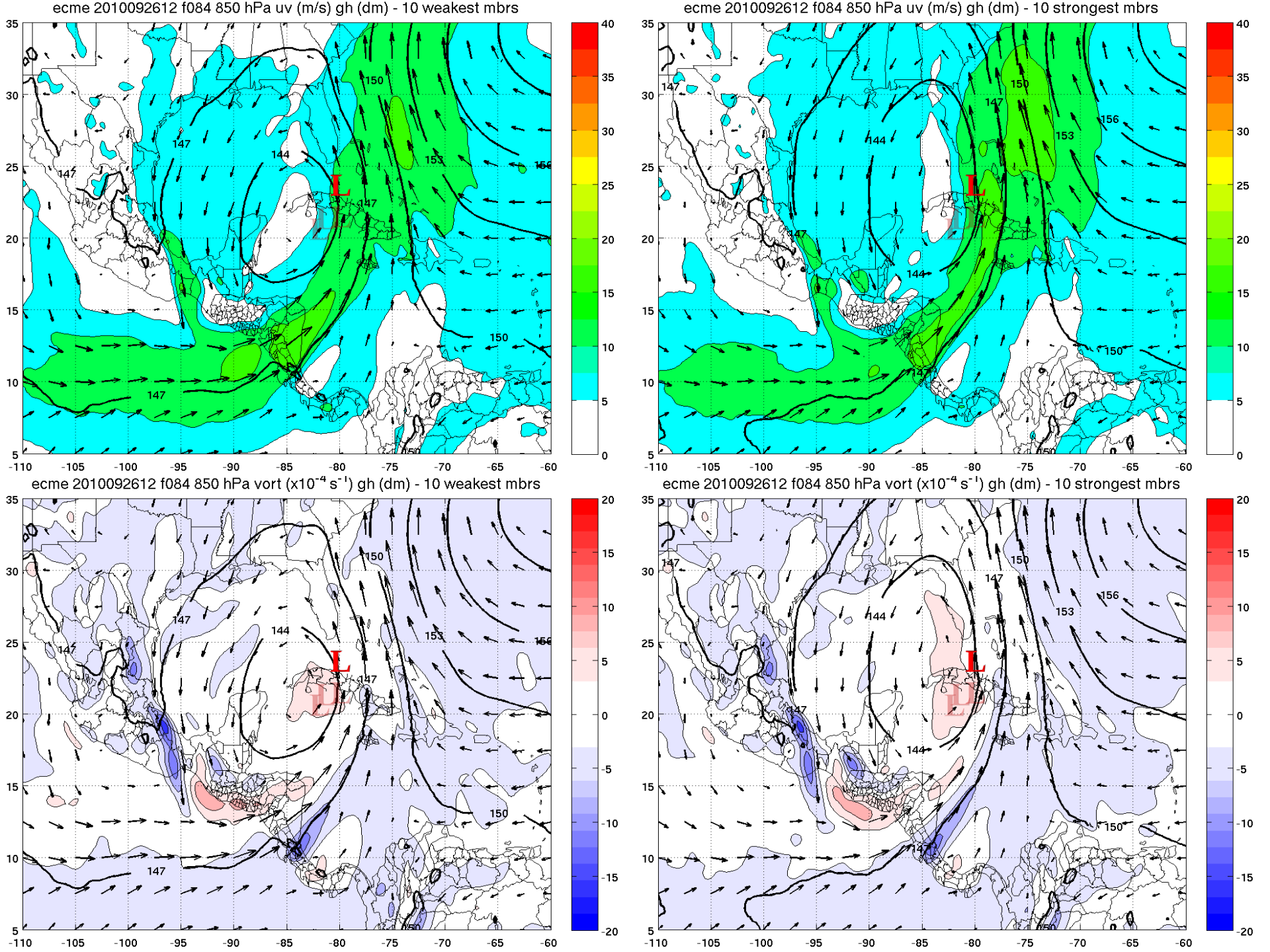


Verifying time of genesis





Note difference in interaction of monsoon trough with midlatitude trough

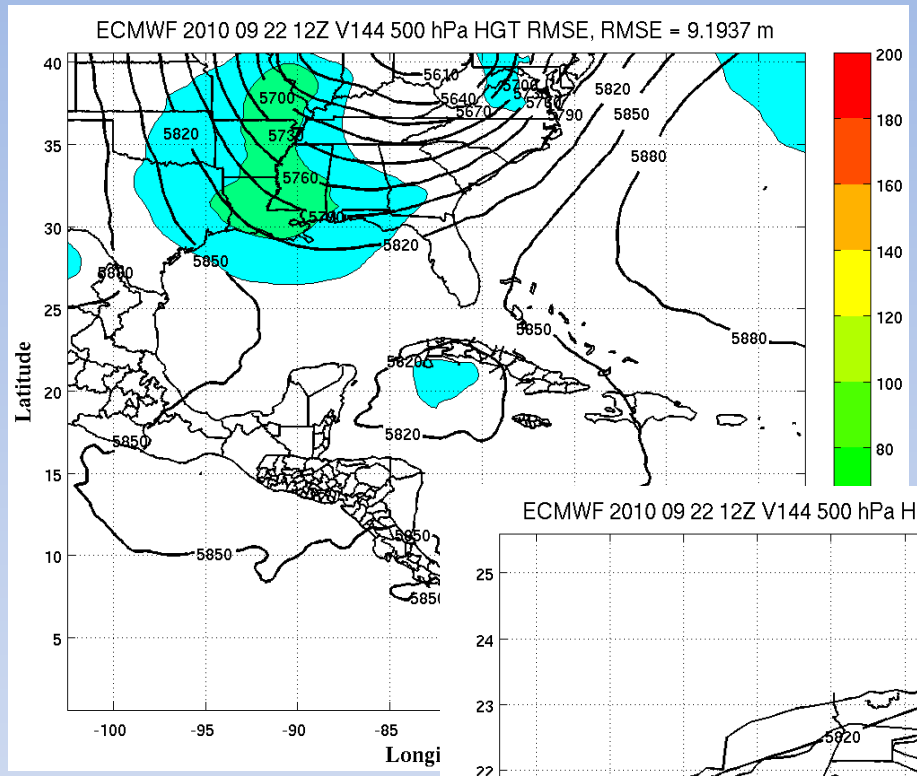

ecme 2010092612 f084 850 hPa uv (m/s) gh (dm) - 10 weakest mbrs
ecme 2010092612 f084 850 hPa uv (m/s) gh (dm) - 10 strongest mbrs
ecme 2010092612 f084 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 weakest mbrs
ecme 2010092612 f084 850 hPa vort (x10^-4 s^-1) gh (dm) - 10 strongest mbrs

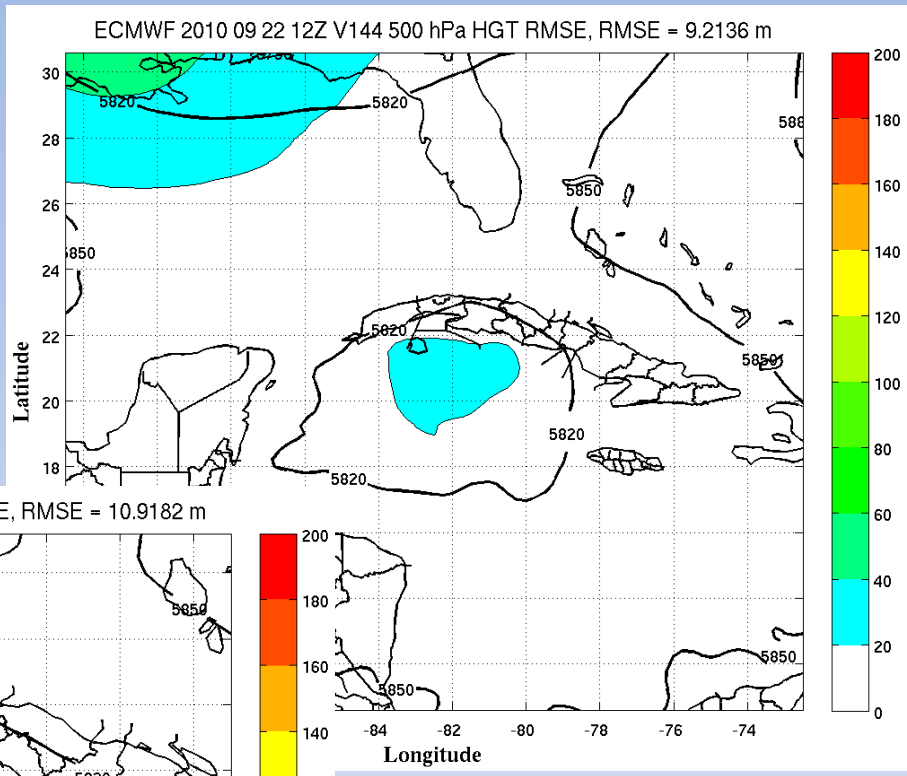
Discussion points

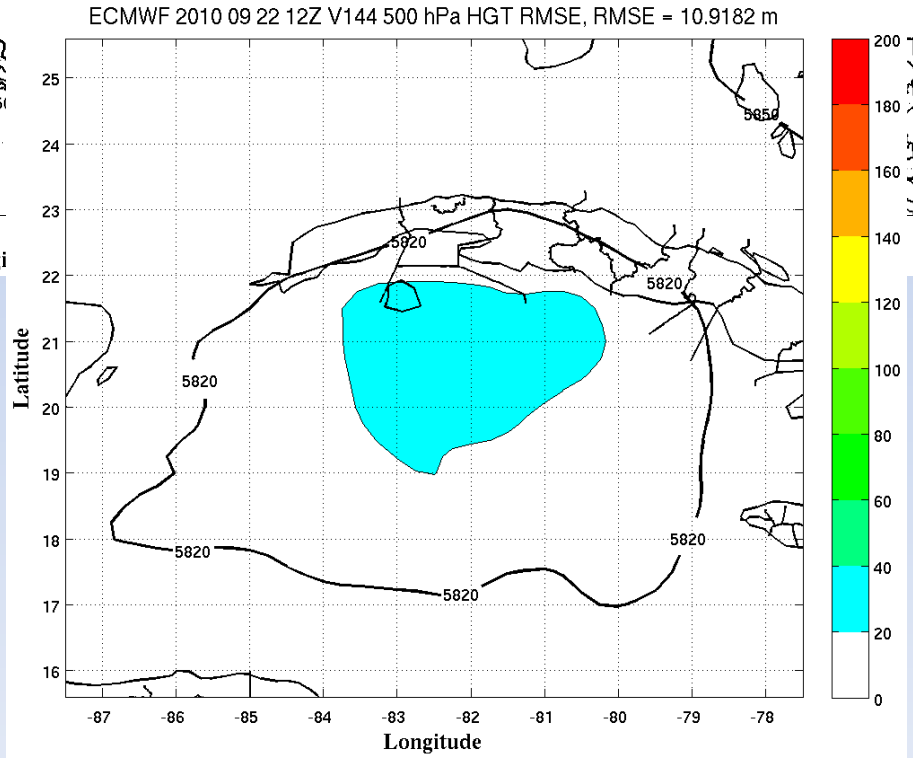
- 10 weakest members do not necessarily have weakest initial disturbance
- Weakest members are slowest to bring vortex over water
  - Genesis is delayed, but not denied
- Genesis occurs too far west (entire ensemble too slow) in mean of both strong and weak ensembles
- Early interaction of monsoon trough with midlatitude trough appears necessary for timely genesis

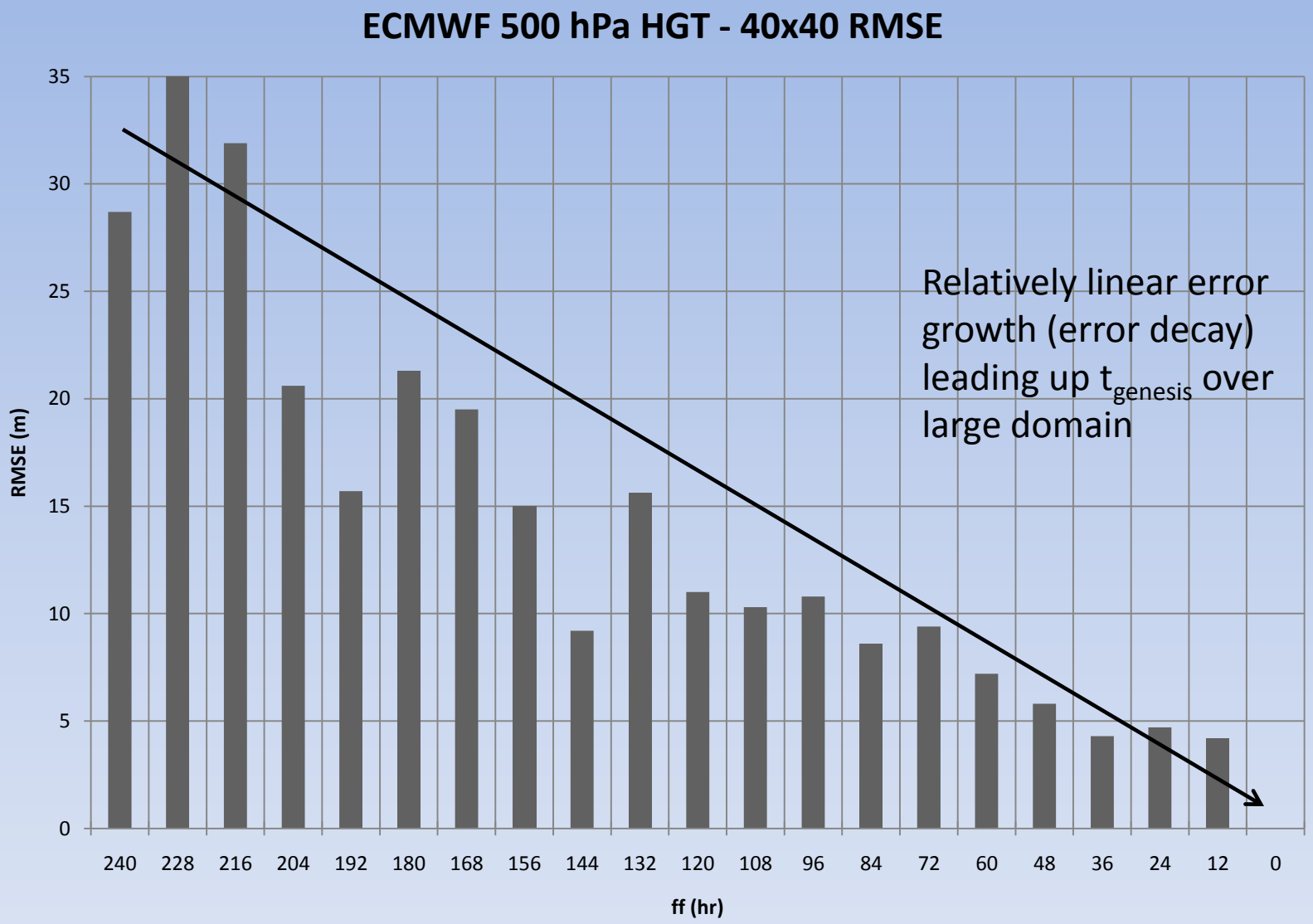
Since tropical cyclogenesis is inherently a multiscale problem, can we quantify the predictability (via error growth) at different spatial scales?

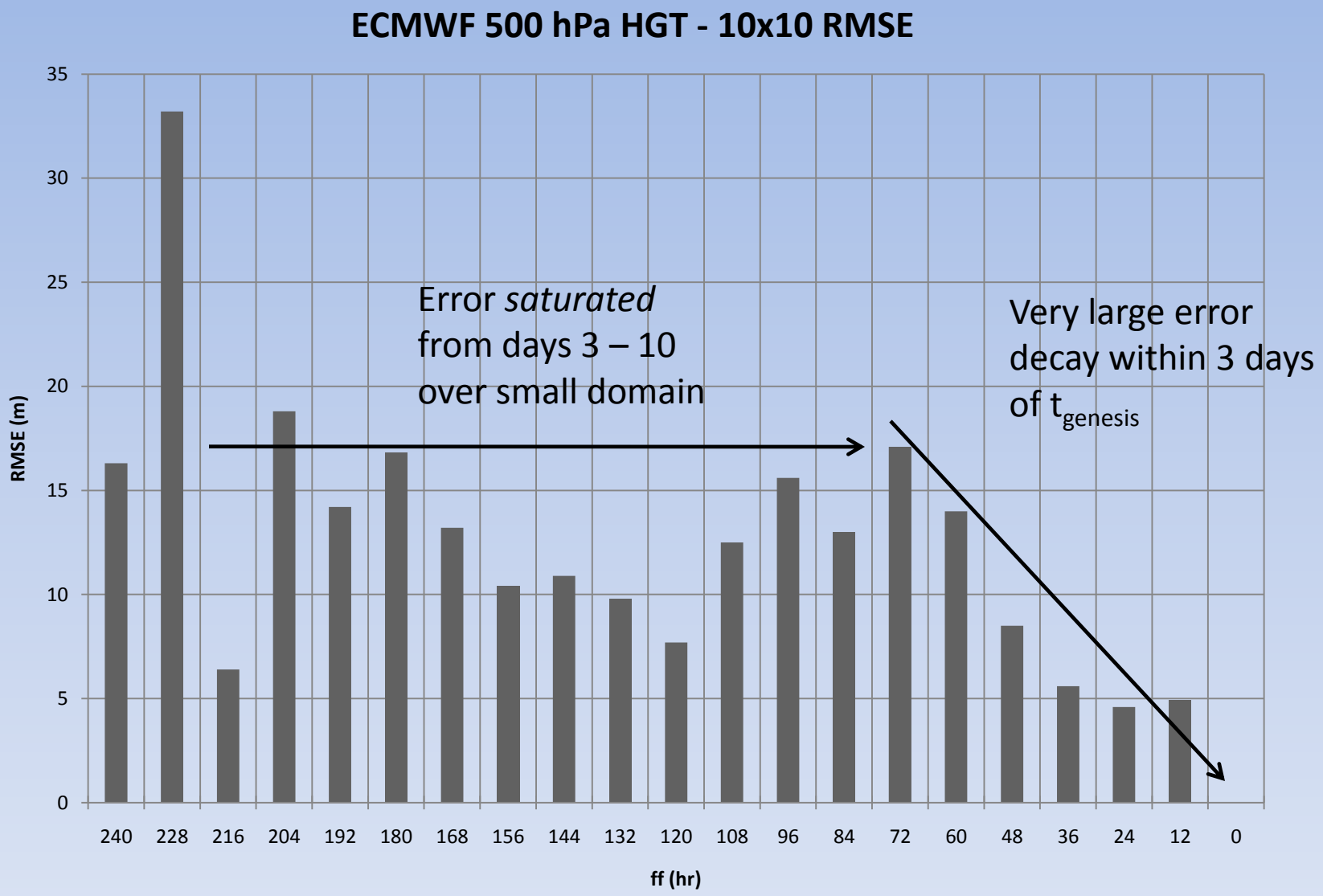
Op. ECMWF average RMS error computed on 40x40 (deg. lat x lon), 20x20 and 10x10 grids centered on Nicole at time of genesis







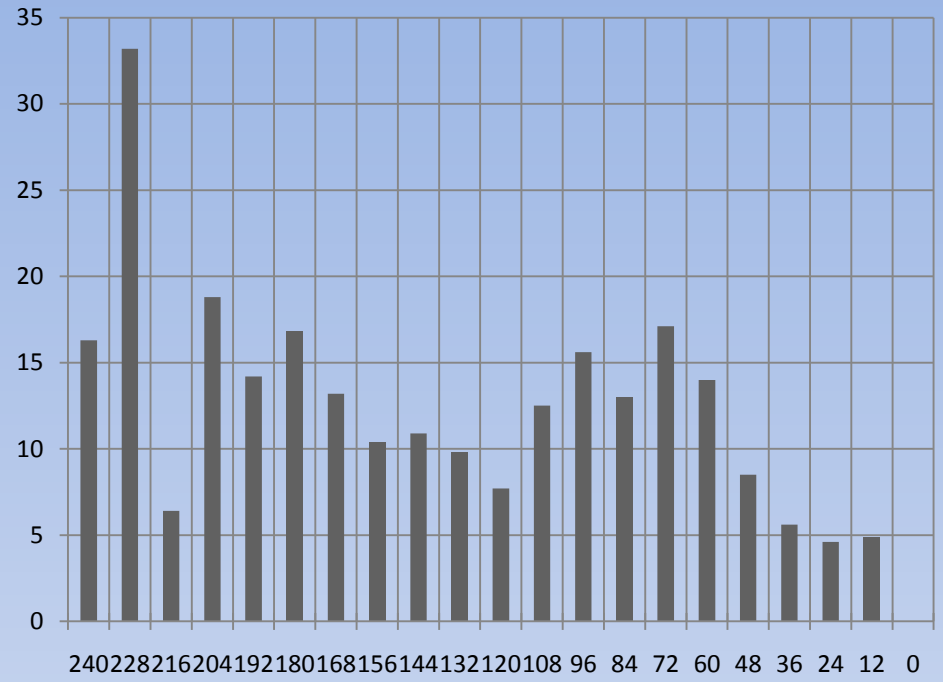

ECMWF 500 hPa HGT - 40x40 RMSE
RMSE (m)
35
30
25
20
15
10
5
0
240
228
216
204
192
180
168
156
144
132
120
108
96
84
72
60
48
36
24
12
0
ff (hr)
Relatively linear error growth (error decay) leading up t genesis over large domain



3-day predictability of small scales?

Future Work

- Calculate error in each member at each t_o and take mean (mean of ensemble errors, NOT error of ensemble mean)
- See if we get similar results to op. ECMWF
- Do we get a more "smoothed" error decay?
- Include vertical shear, moisture sensitivity



- Additional case studies, perhaps entire 2010 season
- Compare / contrast classic easterly wave cases (Earl, Igor, etc) with Karl and Nicole type cases