Climatology of Dvorak Classifications to Support Operational Probabilistic Cyclogenesis Forecasts

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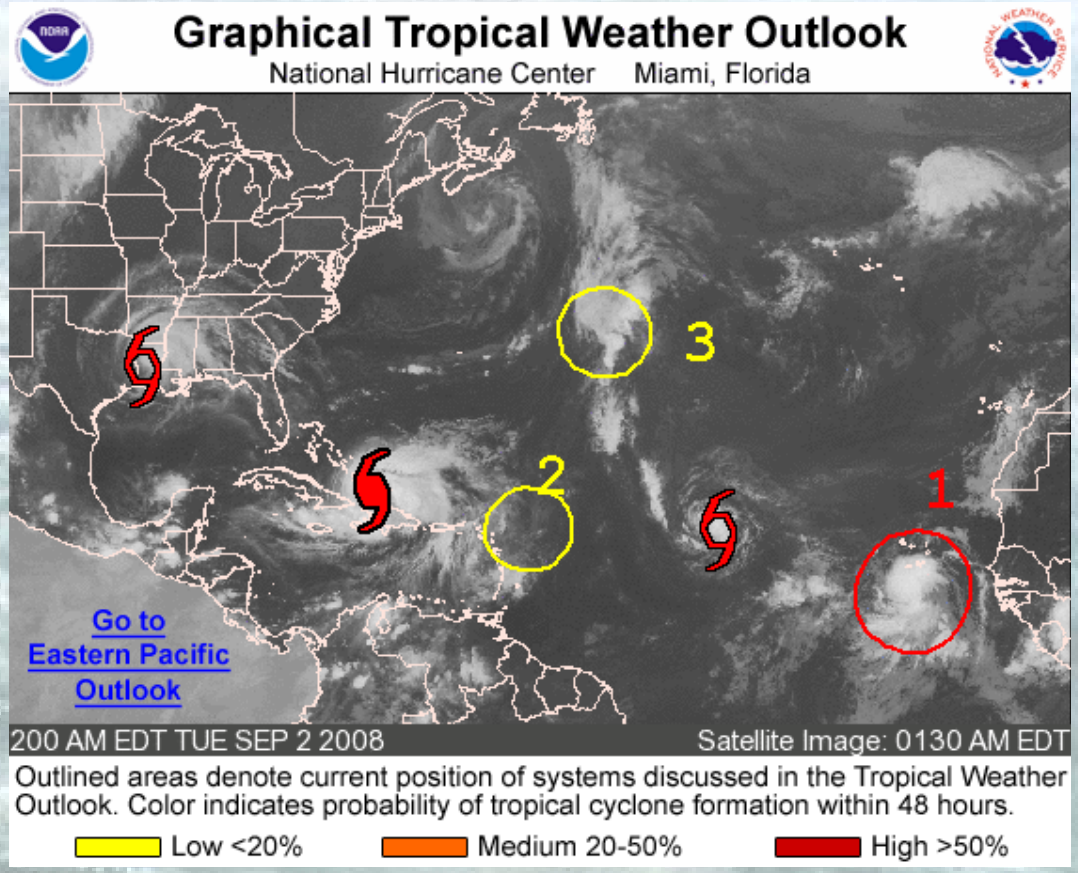
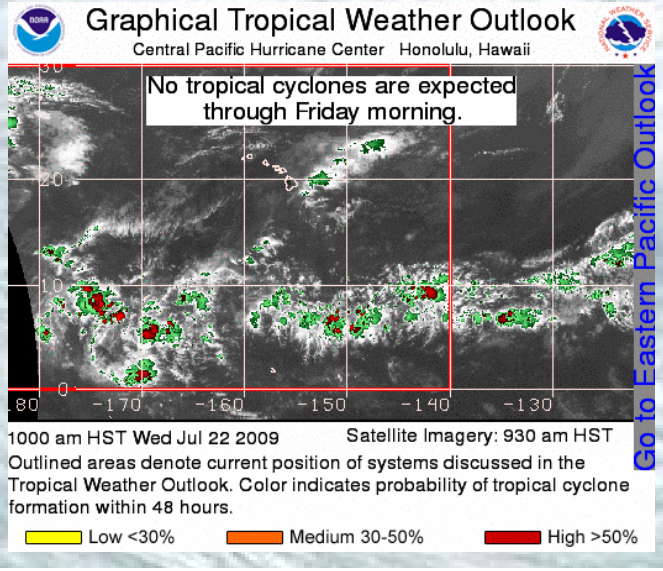
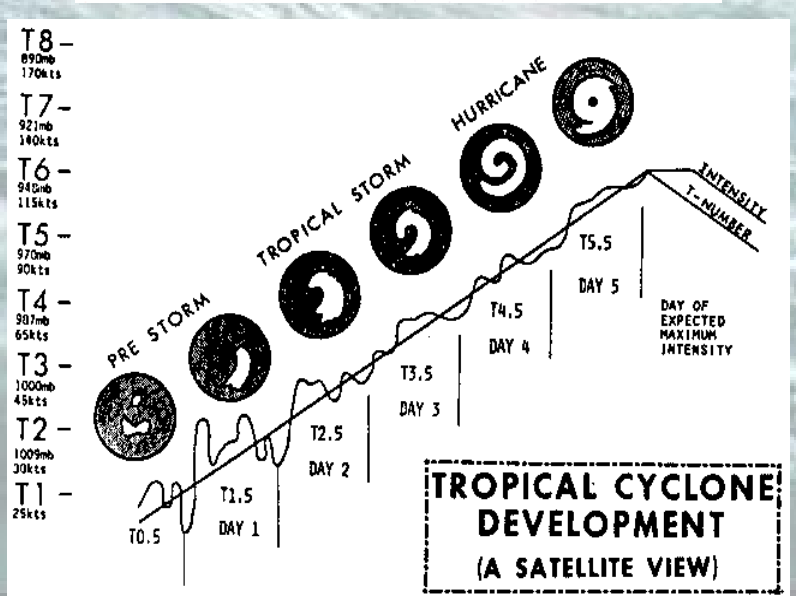
Motivation

- Graphical TWO Probabilities
  - Allows quick visual and geographical review of systems in basin
  - Experimental genesis forecast categories
  - No cyclogenesis climatology previously available to forecasters
  - Build upon foundation of forecast probabilities



Dvorak Technique (1975, 1984, 1995)





- TCs have characteristic cloud patterns that correspond to stages of development and intensities
- Analysis may be performed for **all** tropical disturbances with potential for further development
- Repository of Dvorak estimates for developing and non-developing systems allows tropical cyclogenesis climatology
- May provide operational forecasters some historical benchmarks to compare with current disturbances

Project Outline

- Two Main Objectives
  - Create an archive of all Dvorak fixes, including TCs and non-developing disturbances
  - Determine probabilities of TC genesis by Dvorak classification value
- Application
  - To create a baseline climatology of TC genesis to help operational decision making.
- Initial work started out of CPHC

Acquiring Fix Data

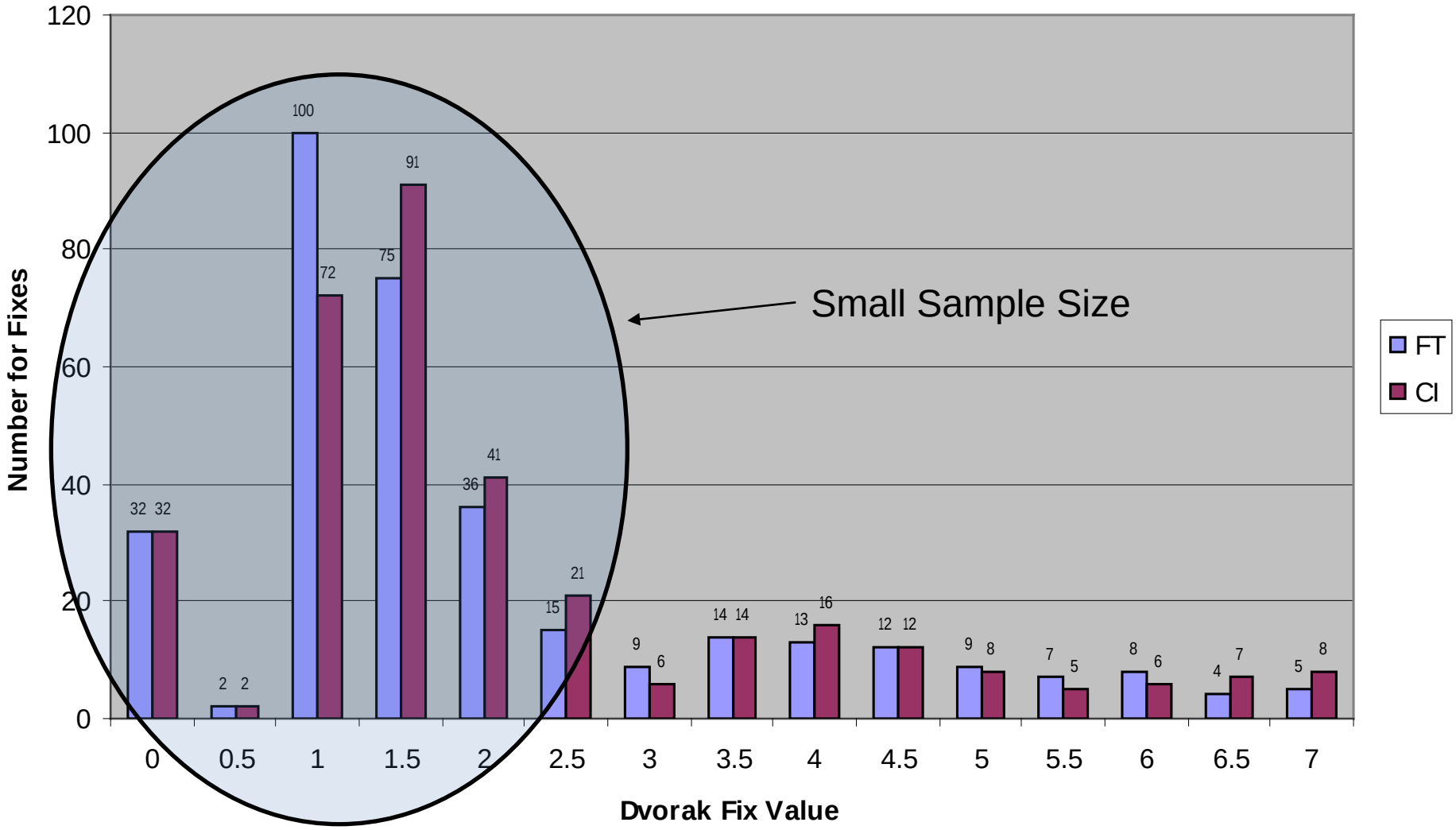
- Tropical Cyclone Summary for North Central Pacific (TCSNP; formerly TCSCP)
  - *Official CPHC public product that disseminates Dvorak analysis*
  - Short electronic archive period contains format changes, inconsistent documentation (3 different versions since 2001)

- TAFB Dvorak Archive for EP and AL
  - 140° W: artificial boundary between cyclone basins; combined east and central Pacific allows more robust data, statistics
  - Electronic fixes for TCs and disturbances since 2003

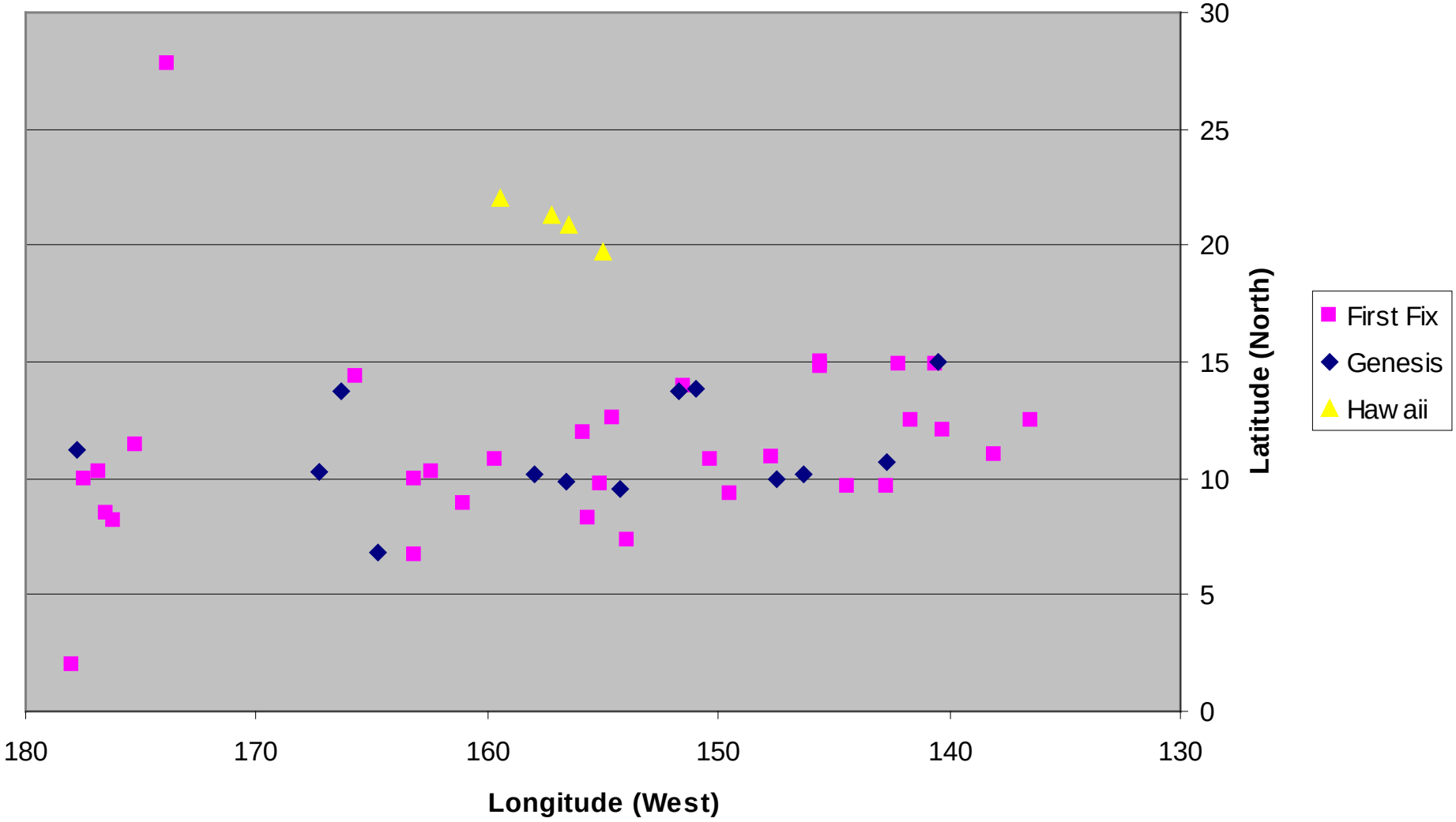
Materials and Methodology (continued)

- ATCF Fix Database
  - Used to append TC Dvorak analyses for 2001 and 2002 in the East Pacific and Atlantic basins
- Manual/Handwritten Dvorak Analysis Worksheet
  - EP and AL fixes for non-developing disturbances from 2001/2002 (courtesy Dan Brown, NHC)
  - More complete record of system analysis (than TCSCP); used to add to Central Pacific database
- Best track information from CPHC, NHC, JTWC

Dvorak Fixes for Central Pacific Systems (2001-2008)

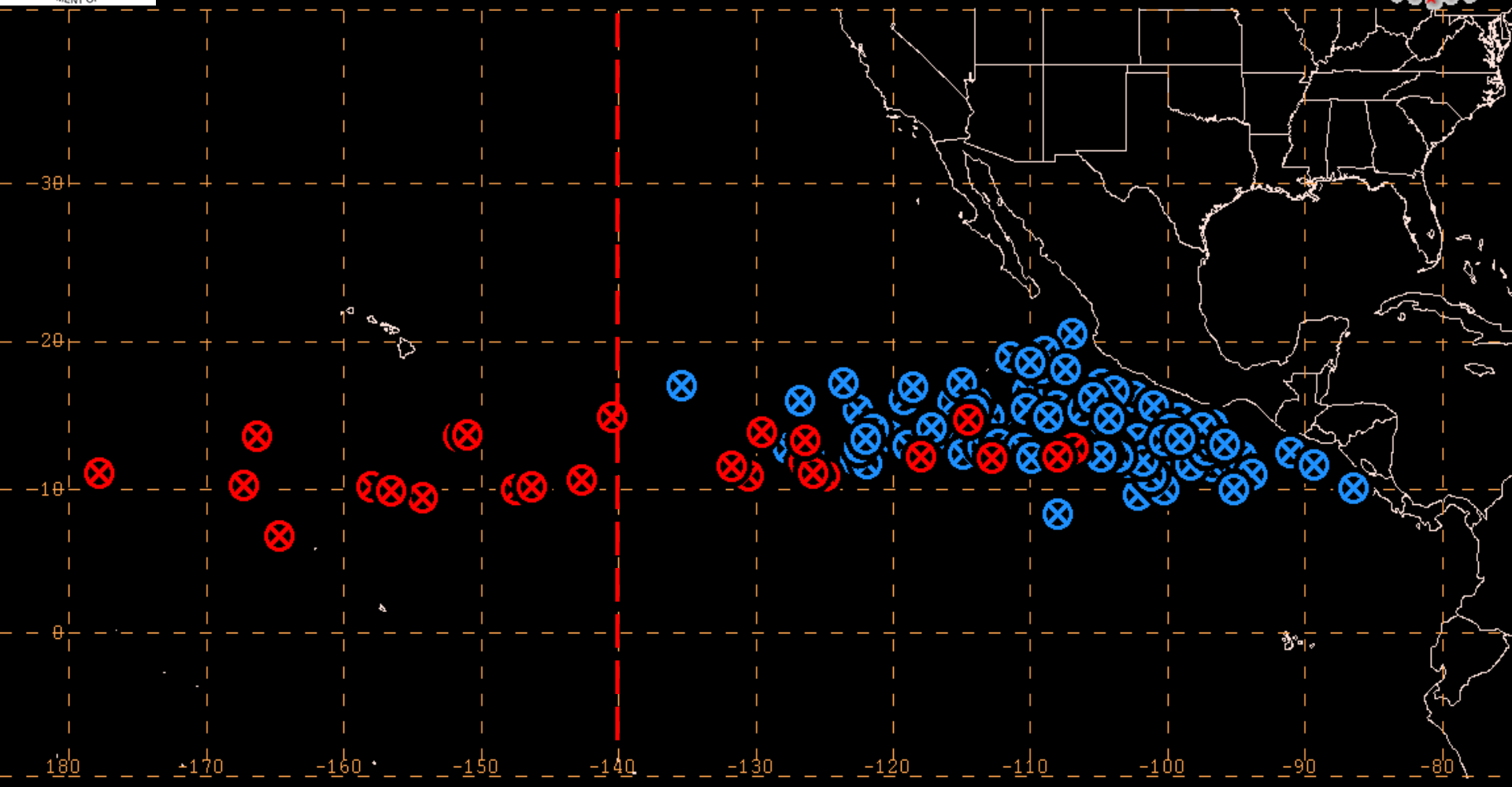


Central Pacific Genesis and First Fixes (2001-2008)



Central and Eastern North Pacific Basins

TROPICAL CYCLOGENESIS POINTS: 2001-2008

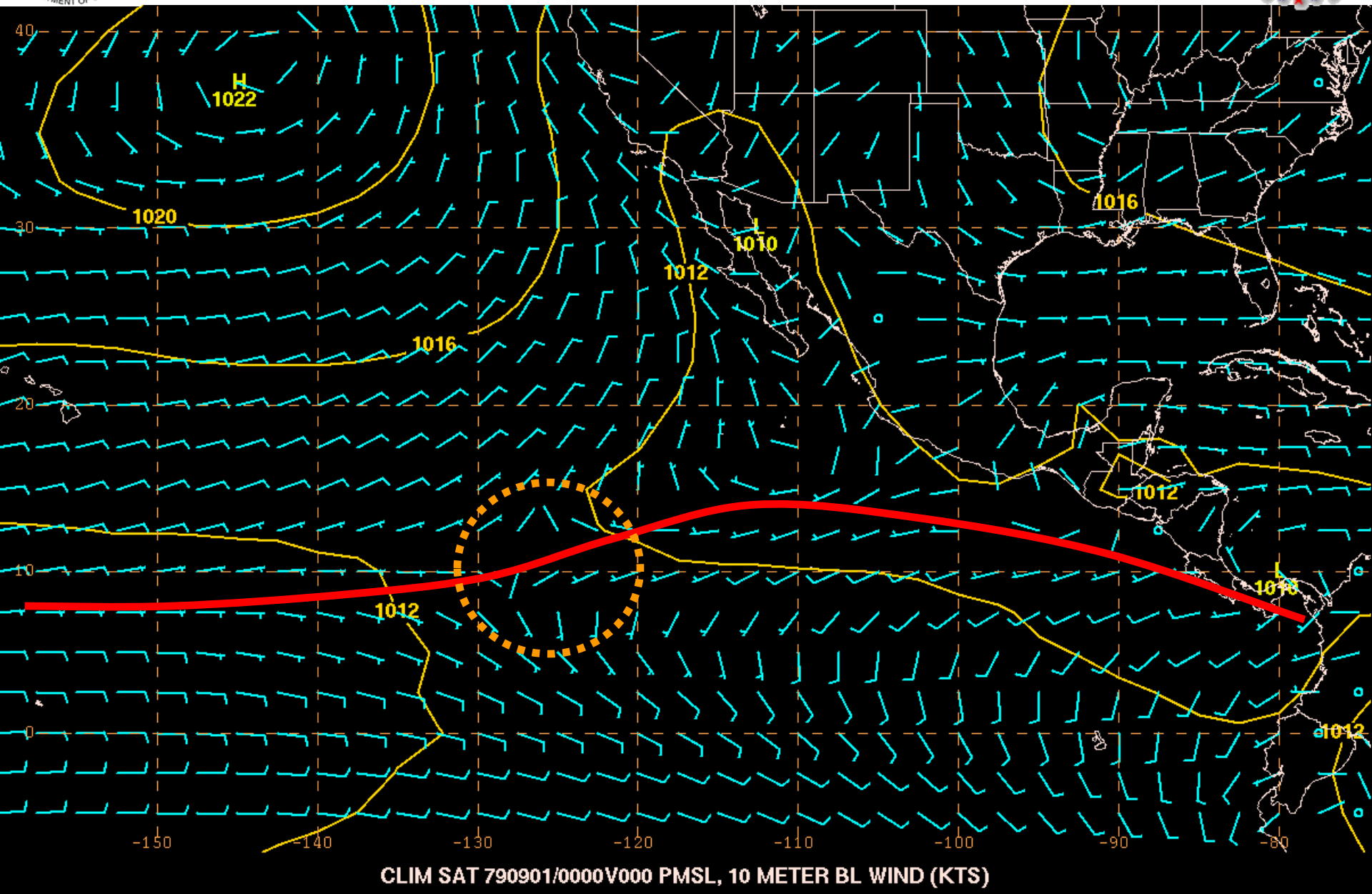


Red markers indicate systems (eventually) reaching central Pacific

East and Central Pacific Dataset

- *4912* Total Dvorak fixes from 2001-2008 in database
  - 88.6% TAFB (Generally in East Pacific)
  - 11.4% CPHC (Generally in Central Pacific)
  - **254** individual systems identified; **148** developed into tropical cyclones
- **125° W** chosen to delineate two separate TC genesis regions
  - Incipient systems that crossed 125° W assigned to western region
  - System traveling about 20 kts will reach CP in 48 Hours
  - Climatological maximum westward extent of SW low level flow from ITCZ
  - Of tropical cyclones that cross into CP from east, half form west of 125° W

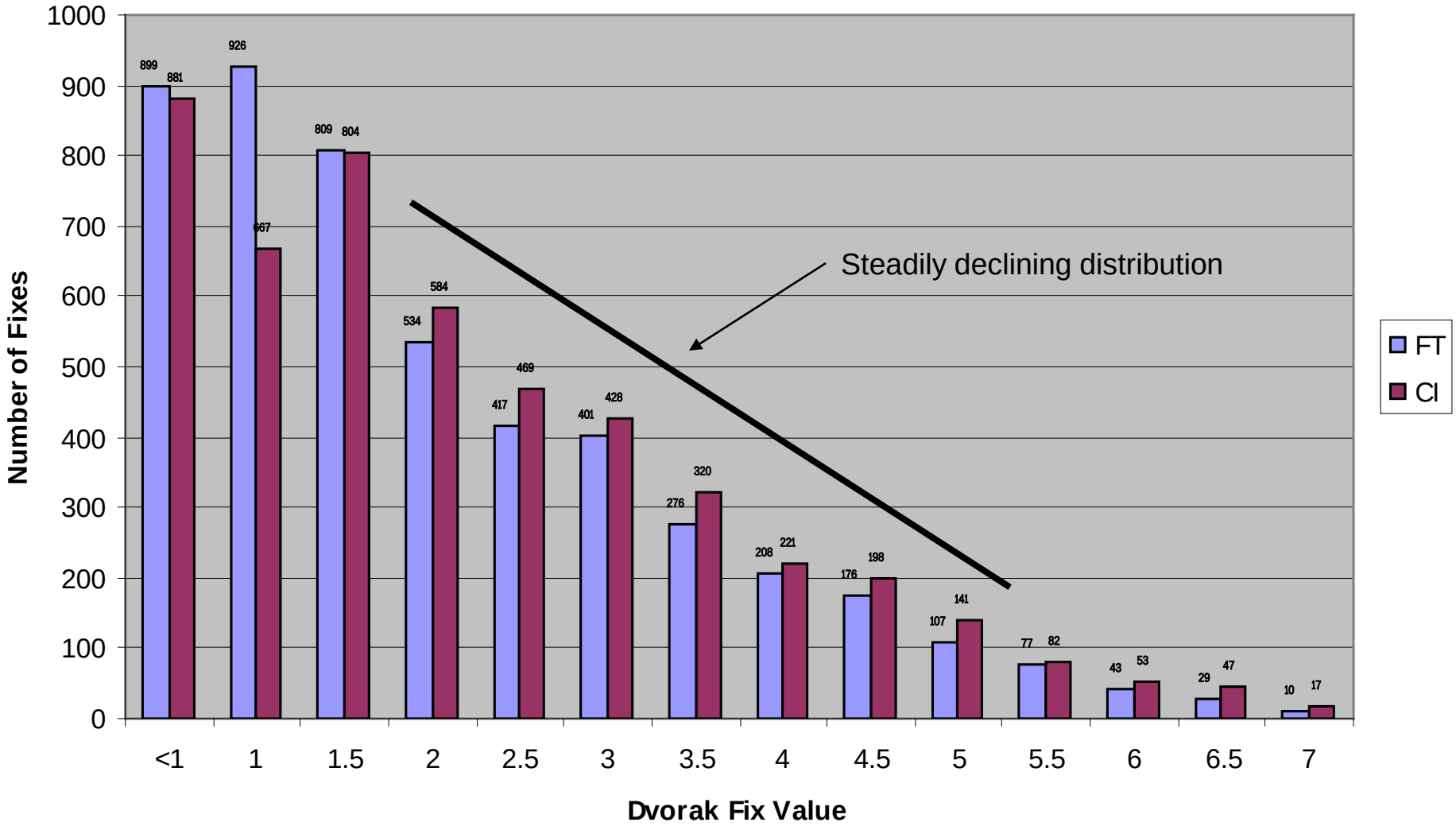
Eastern Pacific ITCZ Climatology (September)



East and Central Pacific Dataset

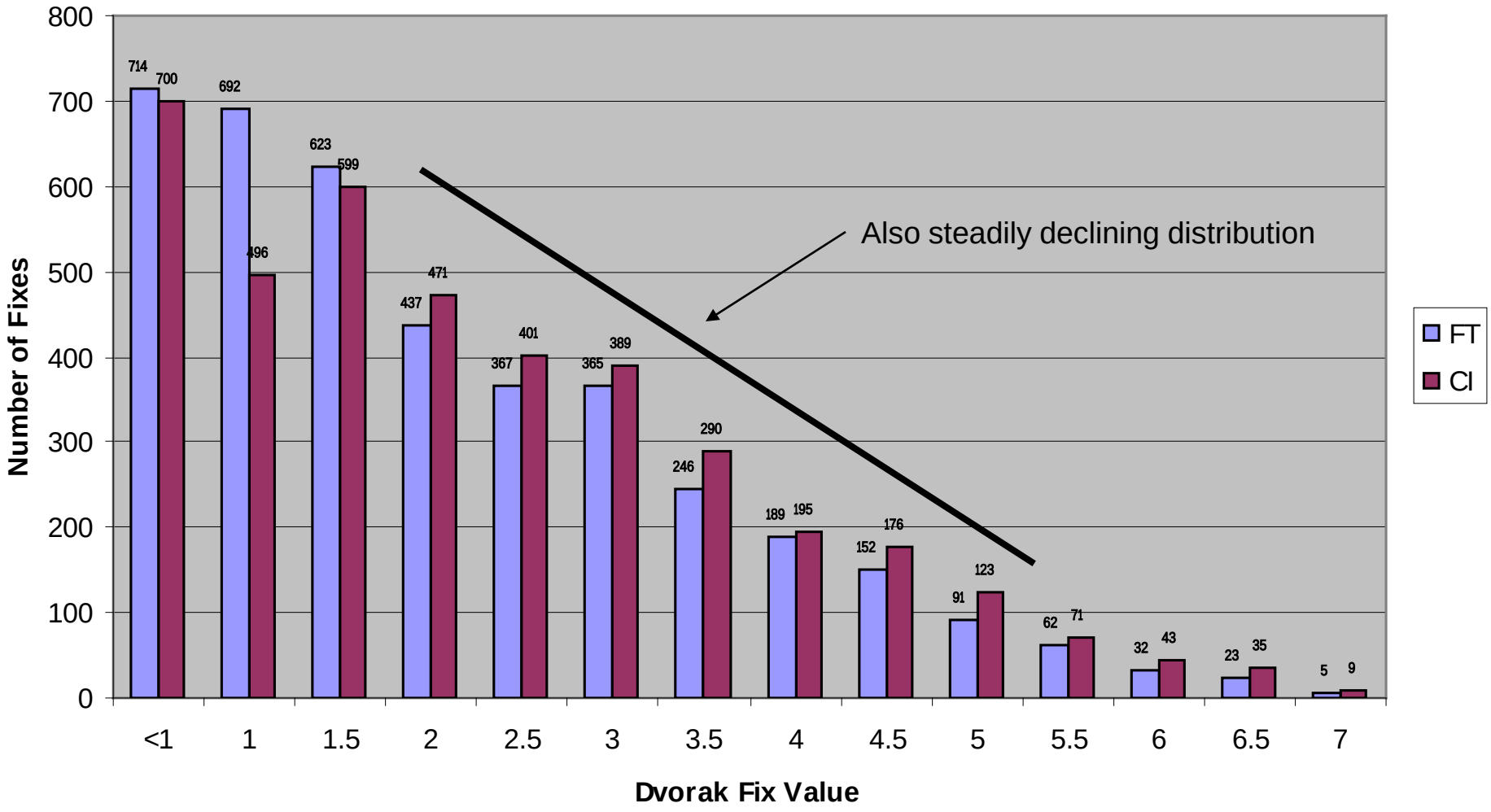
- **3998** Dvorak fixes for **eastern** TC genesis region (east of 125W)
  - 97.7% TAFB 2.3% CPHC
  - 73.2% (186/254) of systems from total database
  - Development Rate: **67.2%** (125/186)
- **914** Dvorak fixes for **'central'** TC genesis region (west of 125W)
  - 48.5% TAFB 51.5% CPHC
  - 26.8% (68/254) of systems from total database
  - Development Rate: **33.8%** (23/68)

East and Central Pacific Dvorak Fixes (2001-2008)



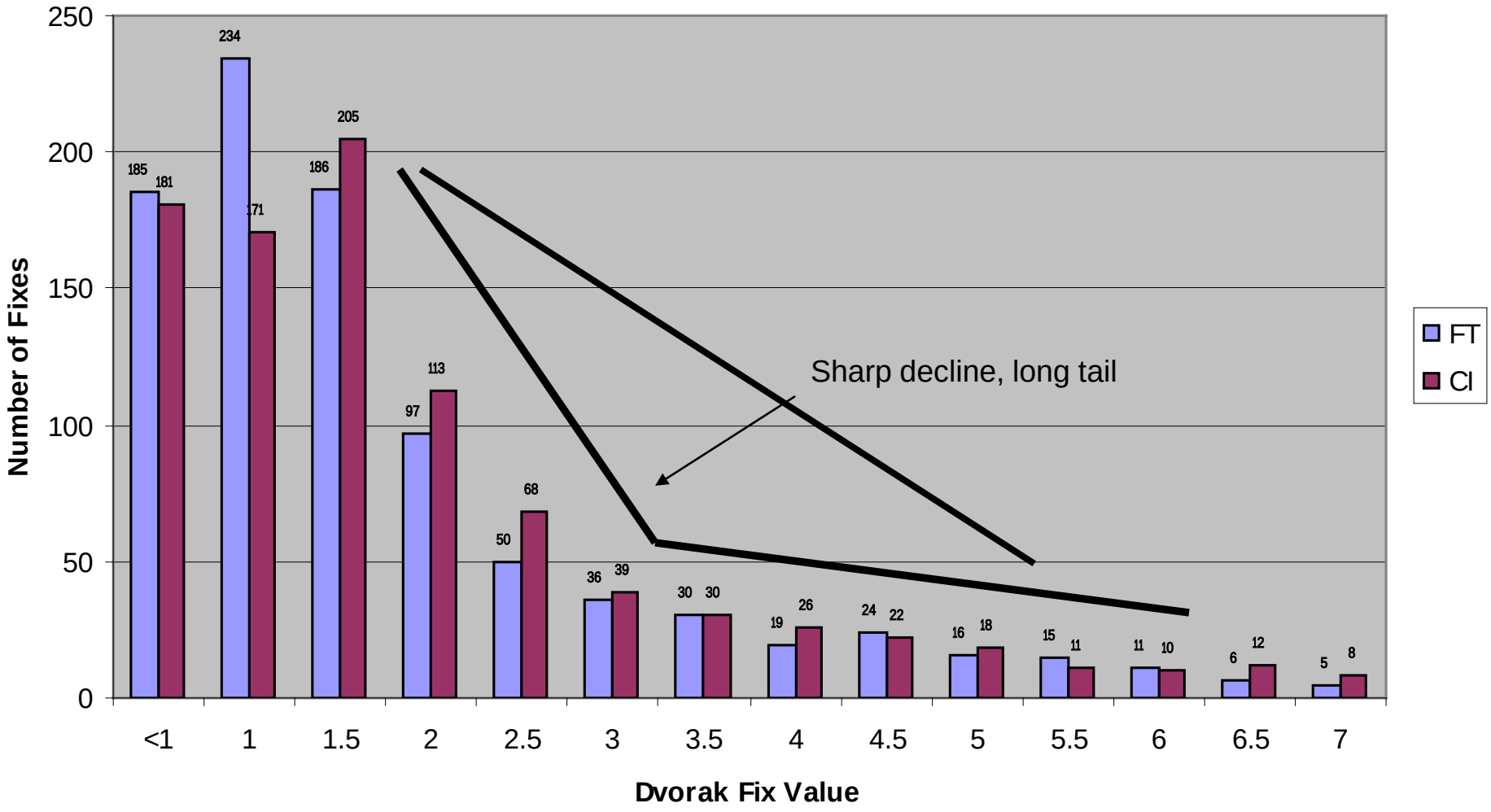
Eastern Pacific Dvorak Fixes (2001-2008)

(Disturbances that did not reach 125°W / TC Genesis east of 125°W)

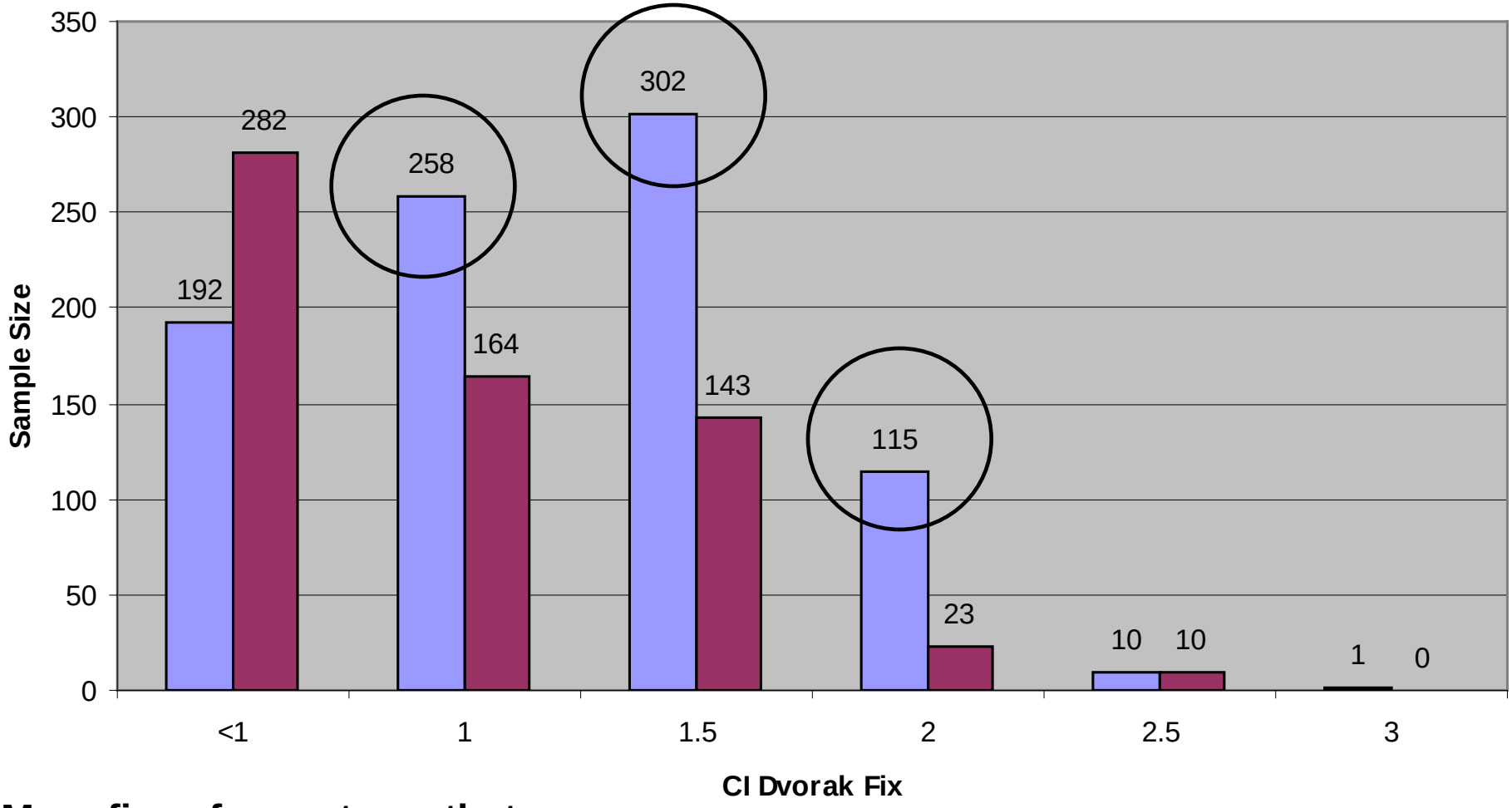


‘Central’ Pacific Dvorak Fixes (2001-2008)

(Disturbances with fixes west of 125ºW / TC Genesis west of 125ºW)

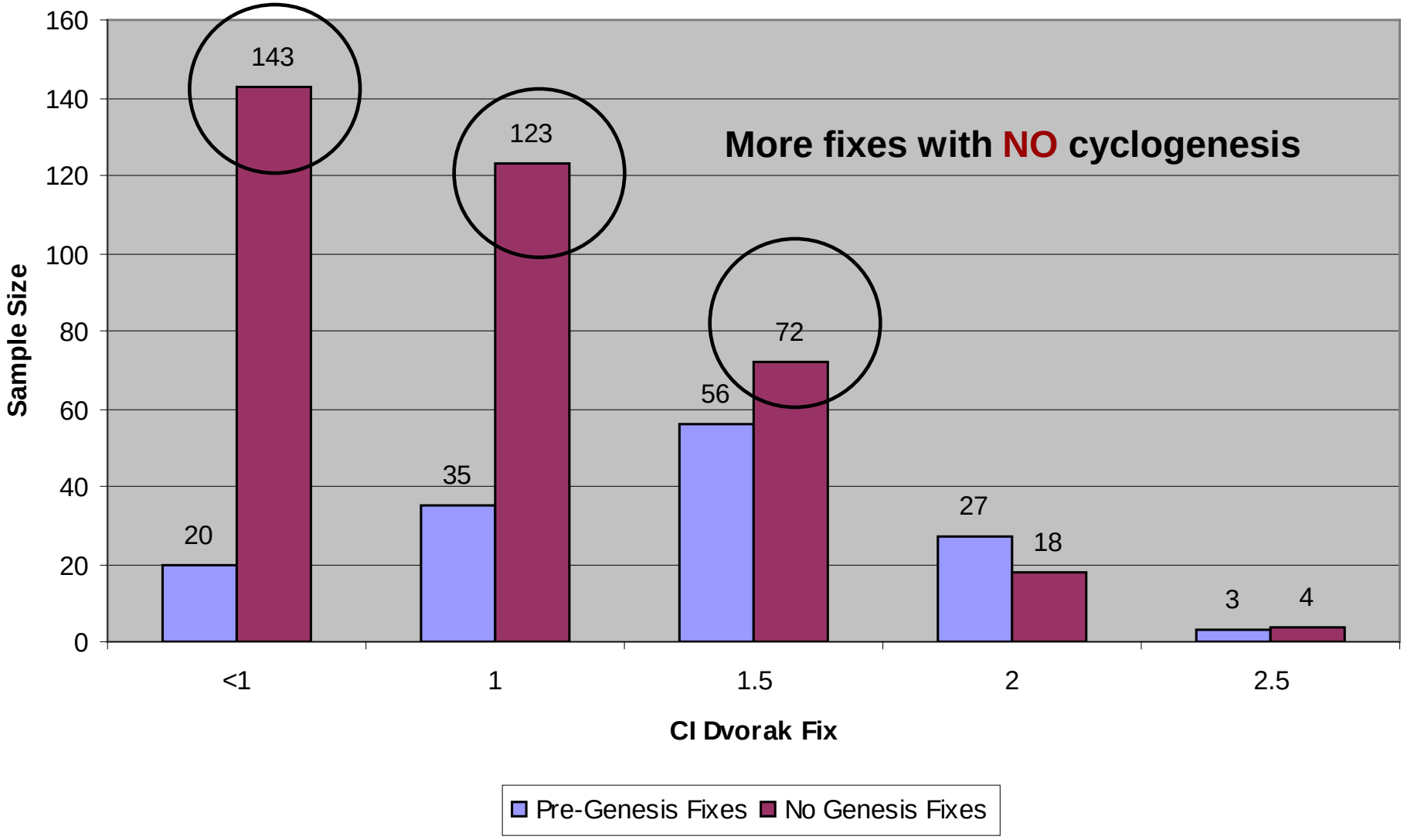


Eastern Pacific Disturbance Dvorak Fixes (2001-2008)

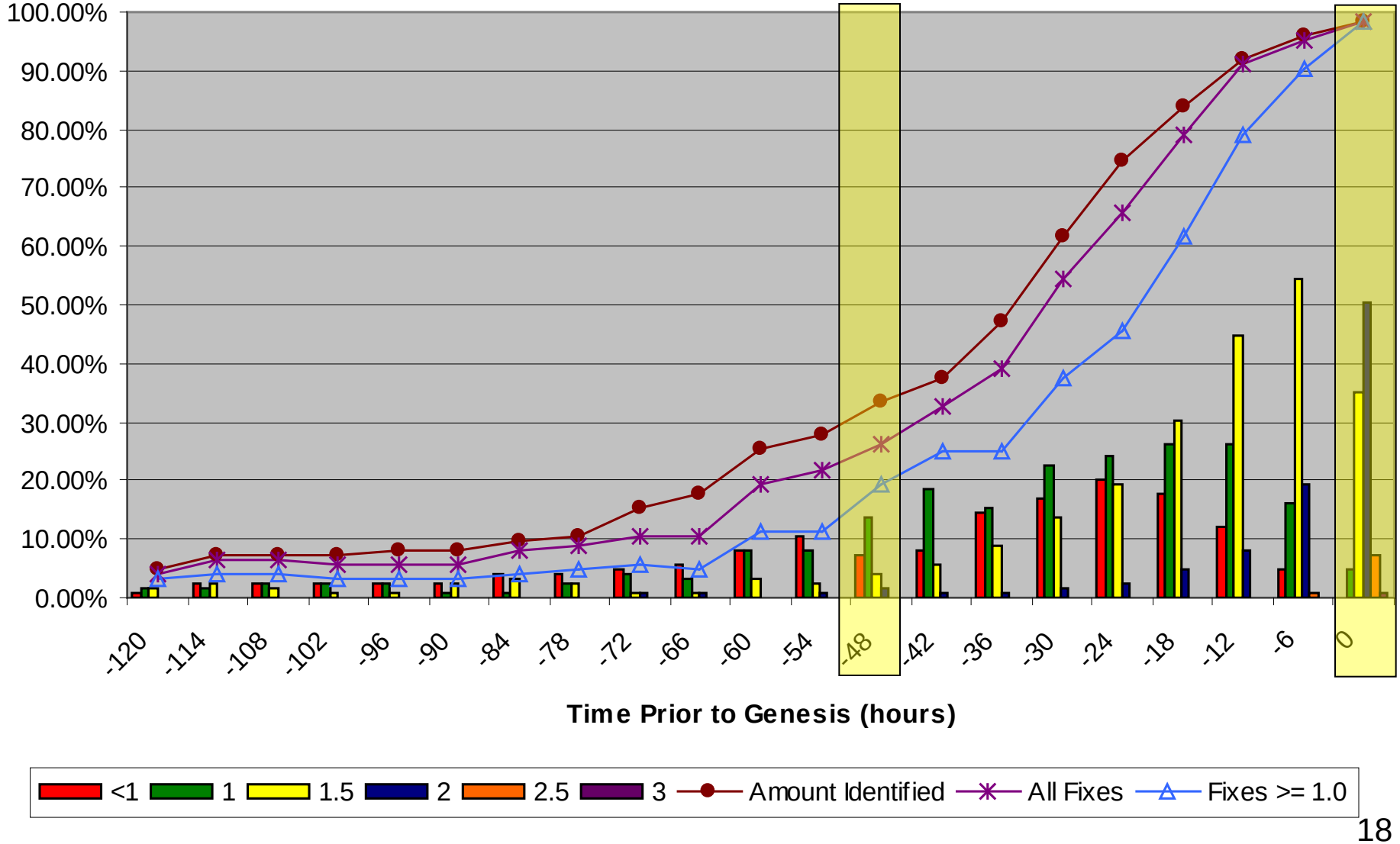


More fixes for systems that will undergo cyclogenesis

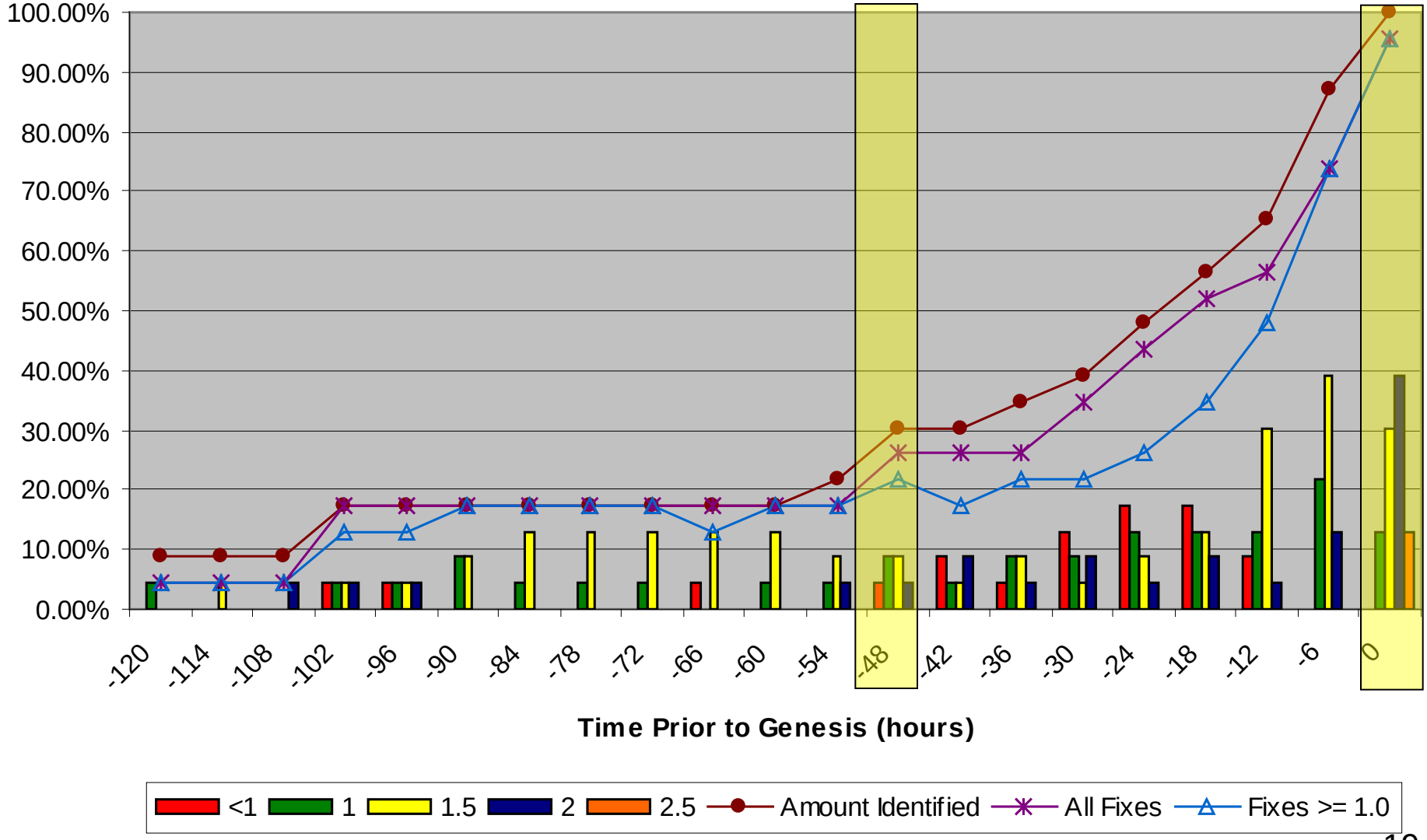
‘Central’ Pacific Disturbance Dvorak Fixes (2001-2008)



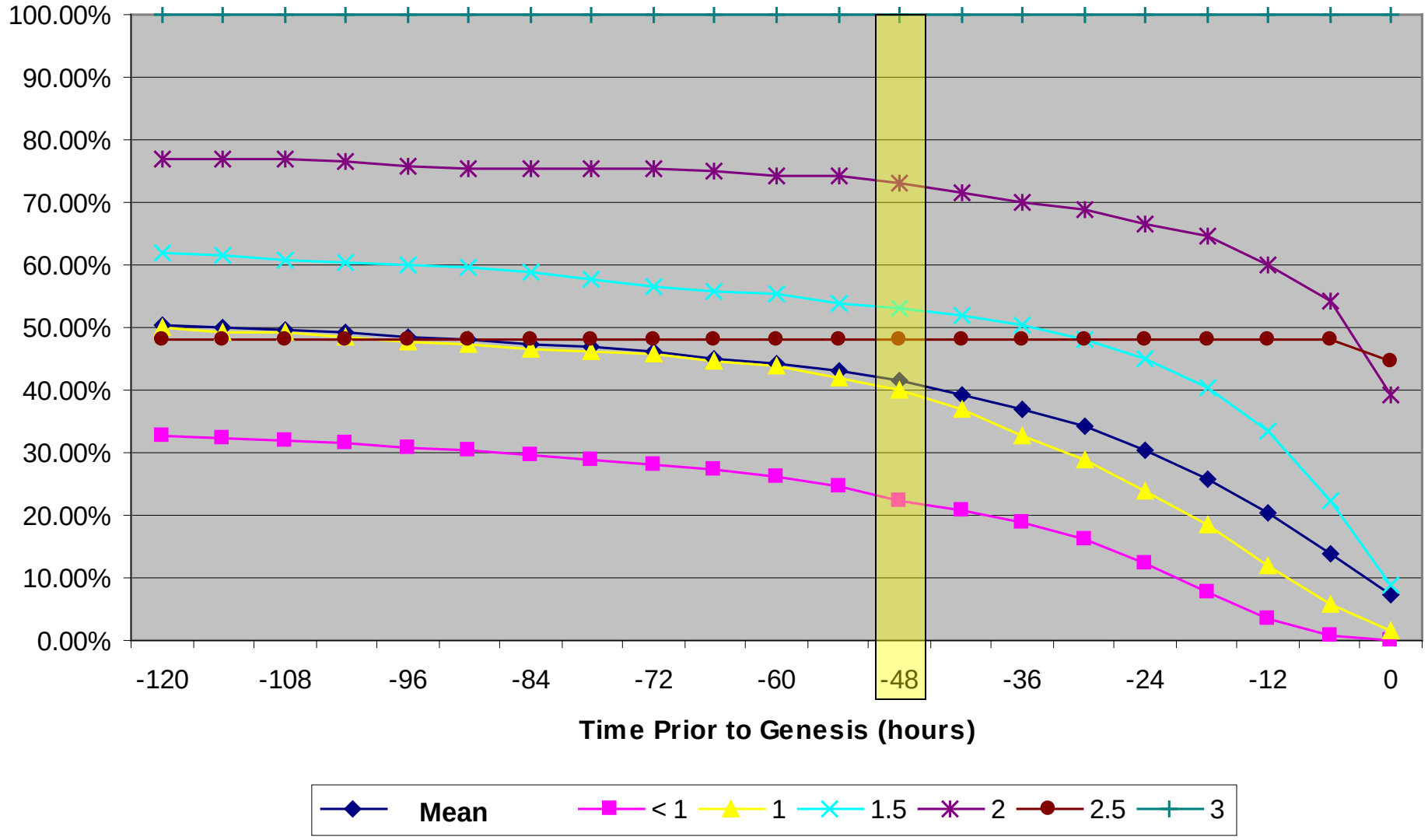
Detection lead time of TCs before genesis, east of 125ºW



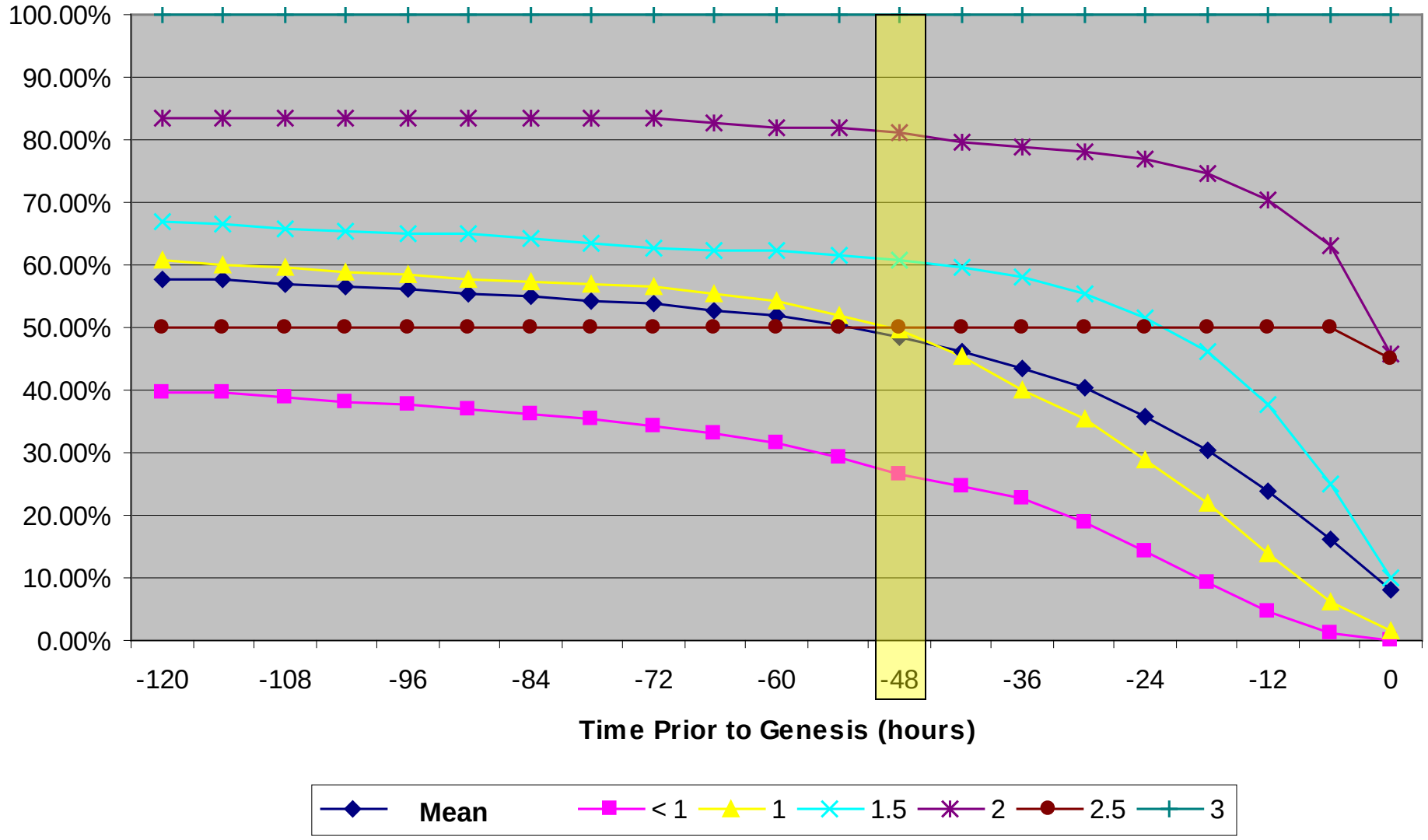
Detection lead time of TCs before genesis, west of 125°W



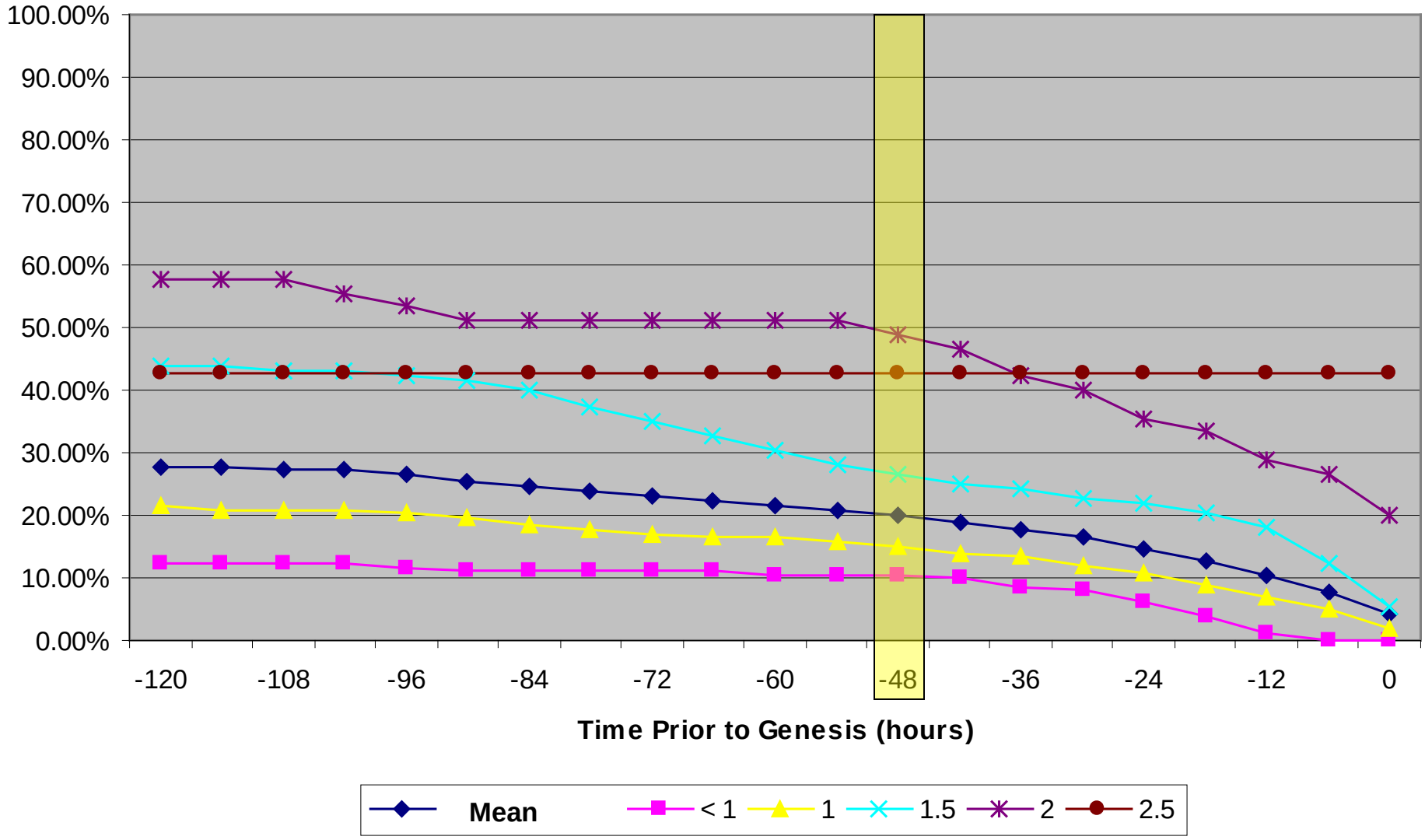
Combined Pacific Cumulative Genesis Probabilities



Eastern Pacific Cumulative Genesis Probabilities



‘Central’ Pacific Cumulative Genesis Probabilities

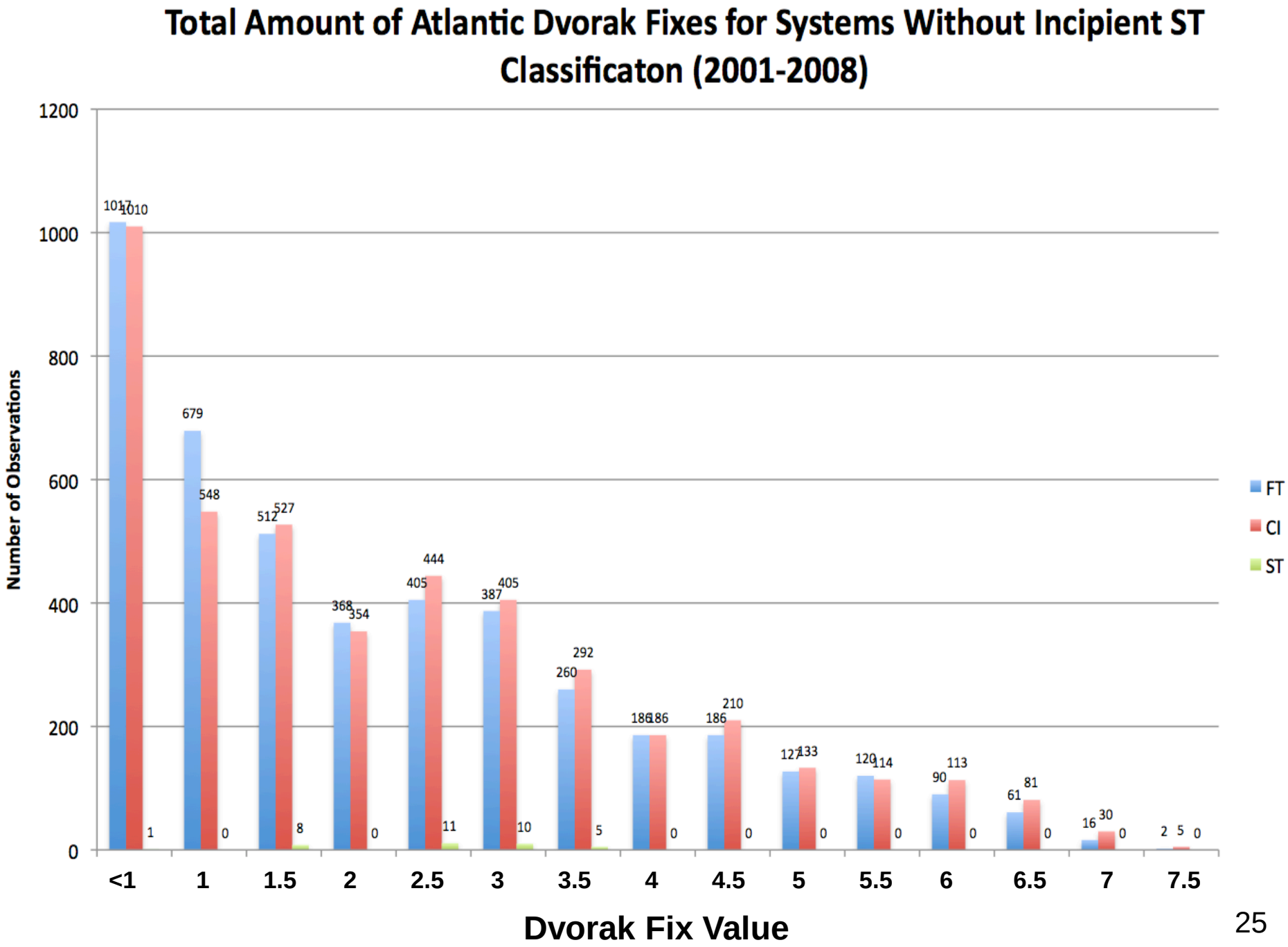


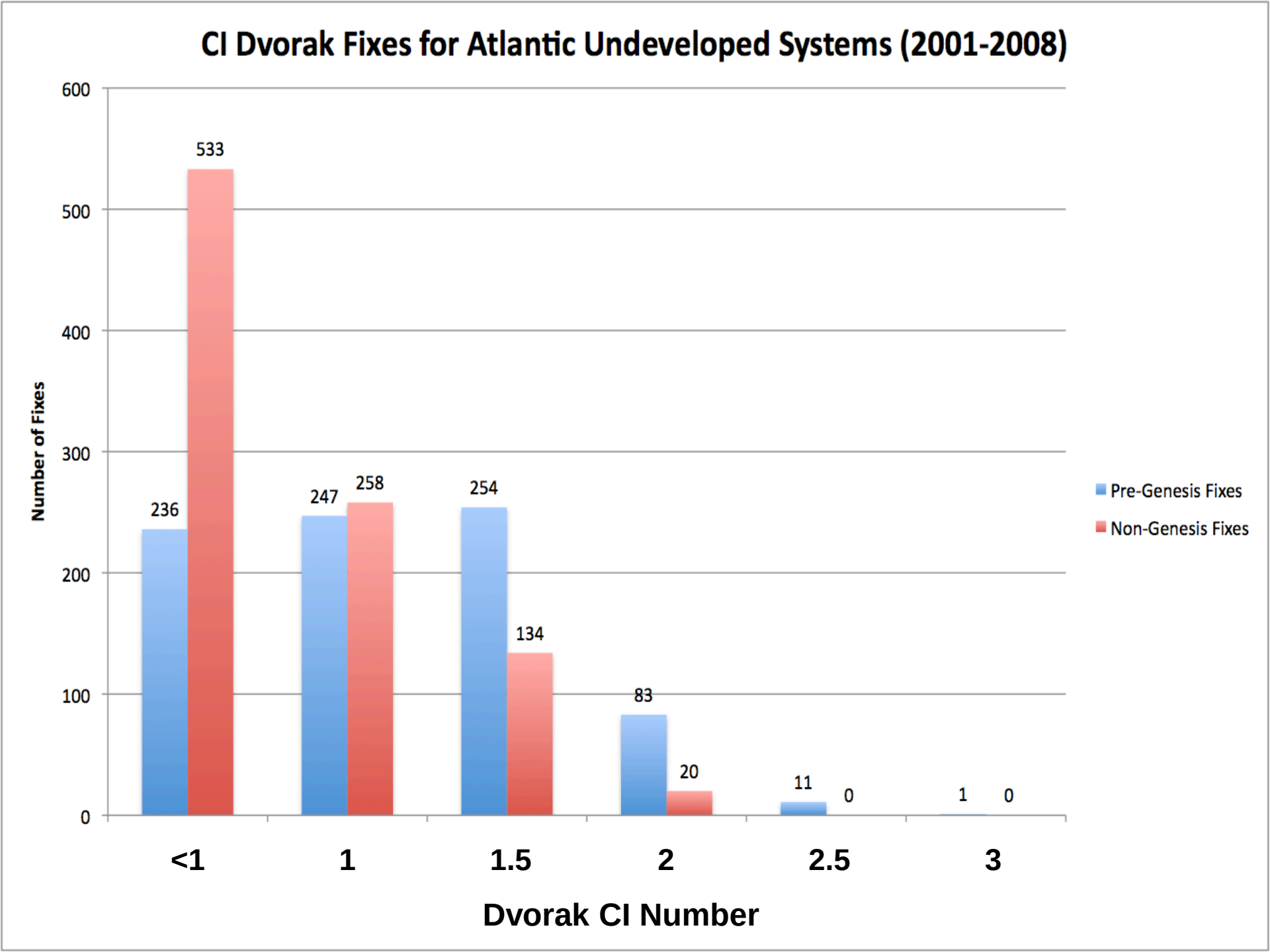
East and Central Pacific Summary

- Different characteristics between east and central Pacific basin disturbances
  - EP: 67.2% development rate, more systems
  - CP: 33.8% development rate, less systems
    - Small sample size; lopsided Dvorak fix distribution
- Climatology of cyclogenesis probabilities
  - EP: In 48h; ~**50**% for 1.0 CI, ~**60**% for 1.5 CI
  - CP: In 48h; ~**15**% for 1.0 CI, ~**25**% for 1.5 CI
    - More potential for forecaster added value (difficult)

Atlantic Dataset

- All fixes from TAFB (2001-2008)
- Any incipient system with at least one ST classification prior to or at genesis (if applicable) was separated from the tropical dataset.
  - Bill (2003) and Delta (2005) included; first ST fix occurred 6 hours after genesis.
- Out of 119 TCs, 6 did not have first Dvorak or position fix prior to or at genesis.
  - (Gaston 2004; Hermine 2004; Zeta 2005; Beryl 2006; Melissa 2007; Marco 2008)


Total Amount of Atlantic Dvorak Fixes for Systems Without Incipient ST Classificaton (2001-2008)
Number of Observations
1200
1000
800
600
400
200
0
1017
1010
1
679
548
0
512
527
8
368
354
0
405
444
11
387
405
10
260
292
5
186
186
0
186
210
0
127
133
0
120
114
0
90
113
0
61
81
0
16
30
0
2
5
0
<1
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Dvorak Fix Value
FT
CI
ST

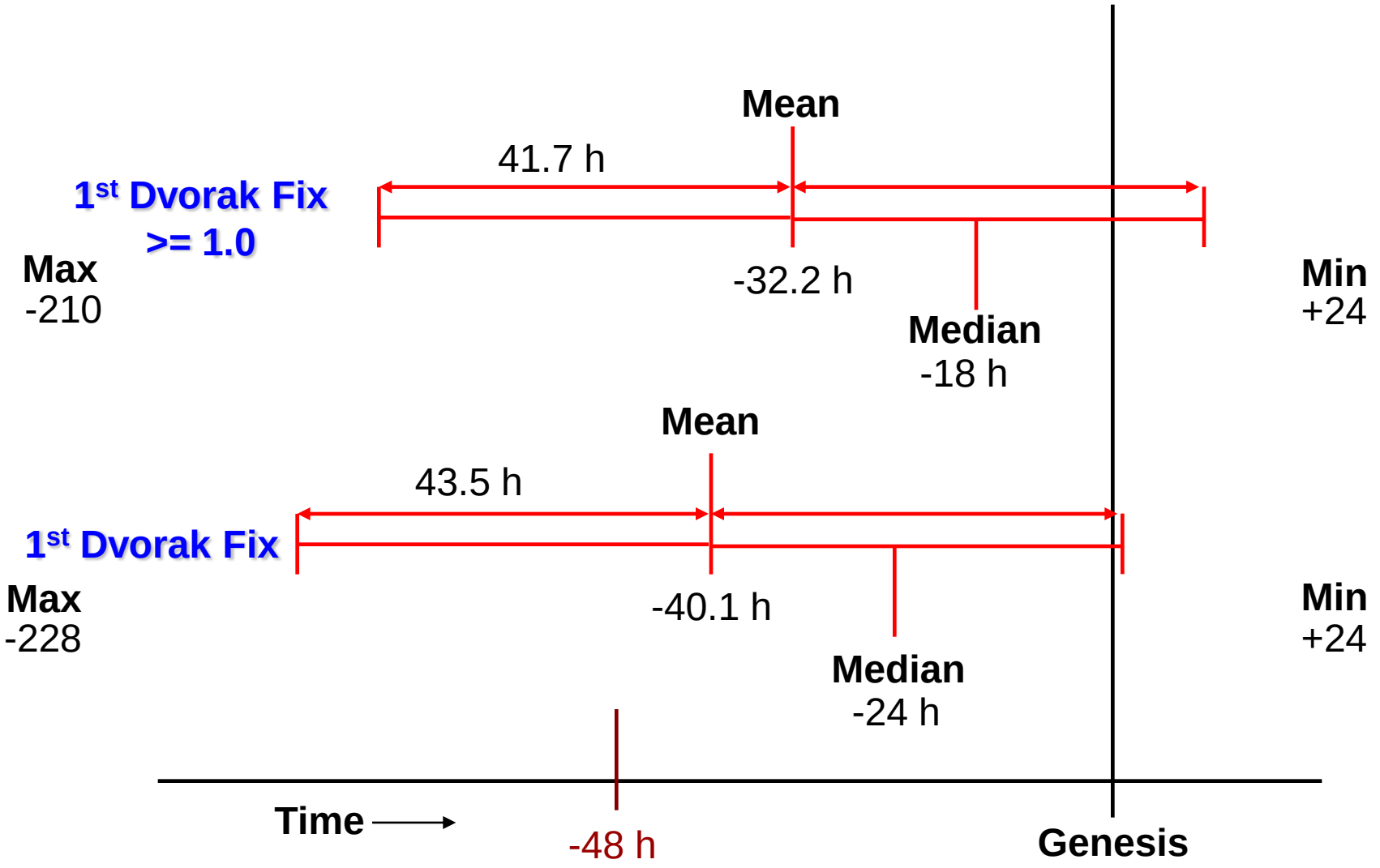

CI Dvorak Fixes for Atlantic Undeveloped Systems (2001-2008)
Number of Fixes
600
500
400
300
200
100
0
533
236
247
258
254
134
83
20
11
0
1
0
<1
1
1.5
2
2.5
3
Dvorak CI Number
Pre-Genesis Fixes
Non-Genesis Fixes

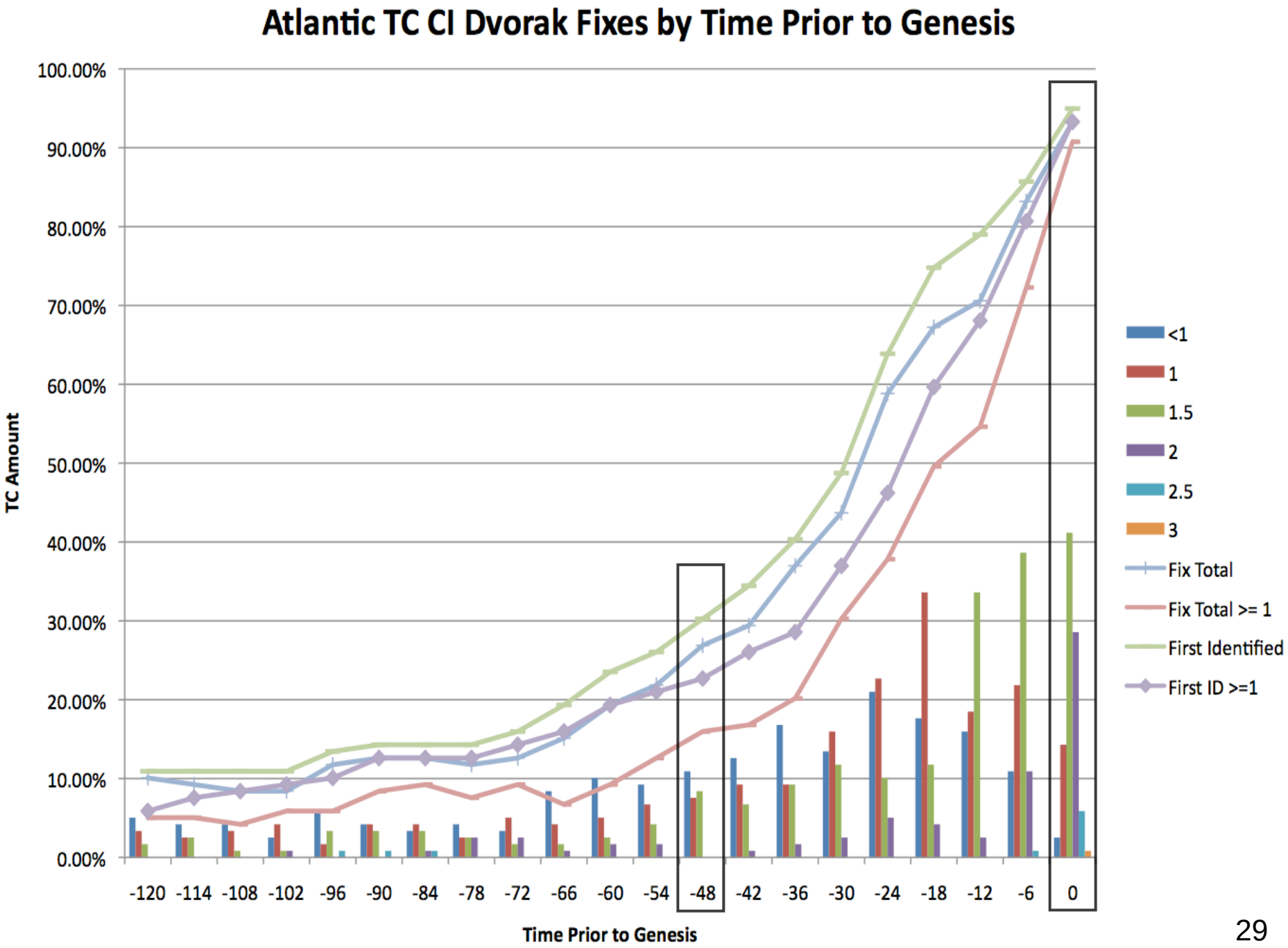
Additional Information

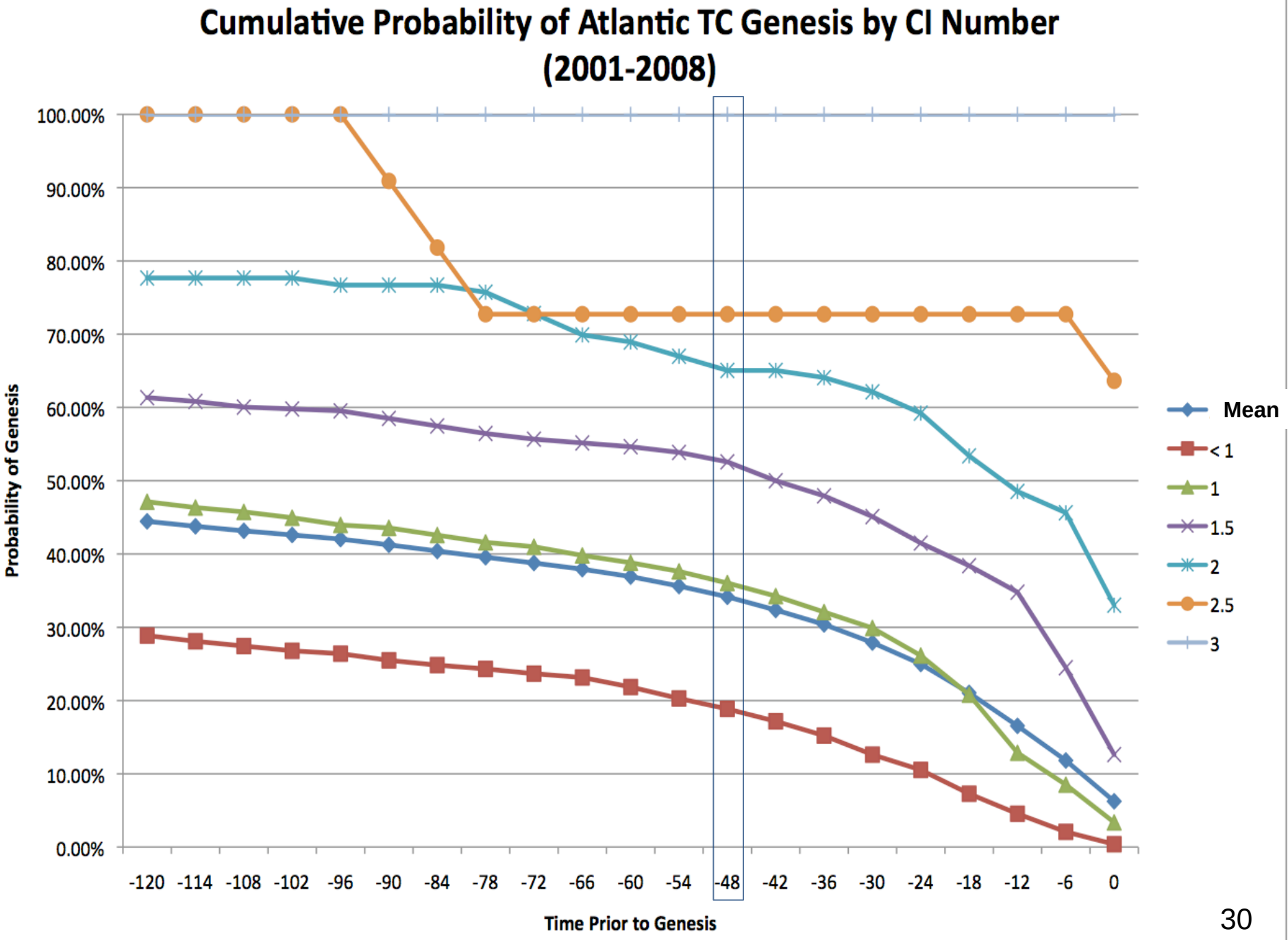
Statistics on systems without incipient ST classification

Total TC Count	119
Non-Develop Count	123
Unique Systems	242
TC Genesis Rate	49.17%
Total Fix Count	4452
Incipient Fix Count	1777

Lead-time to Genesis from First Dvorak Fix



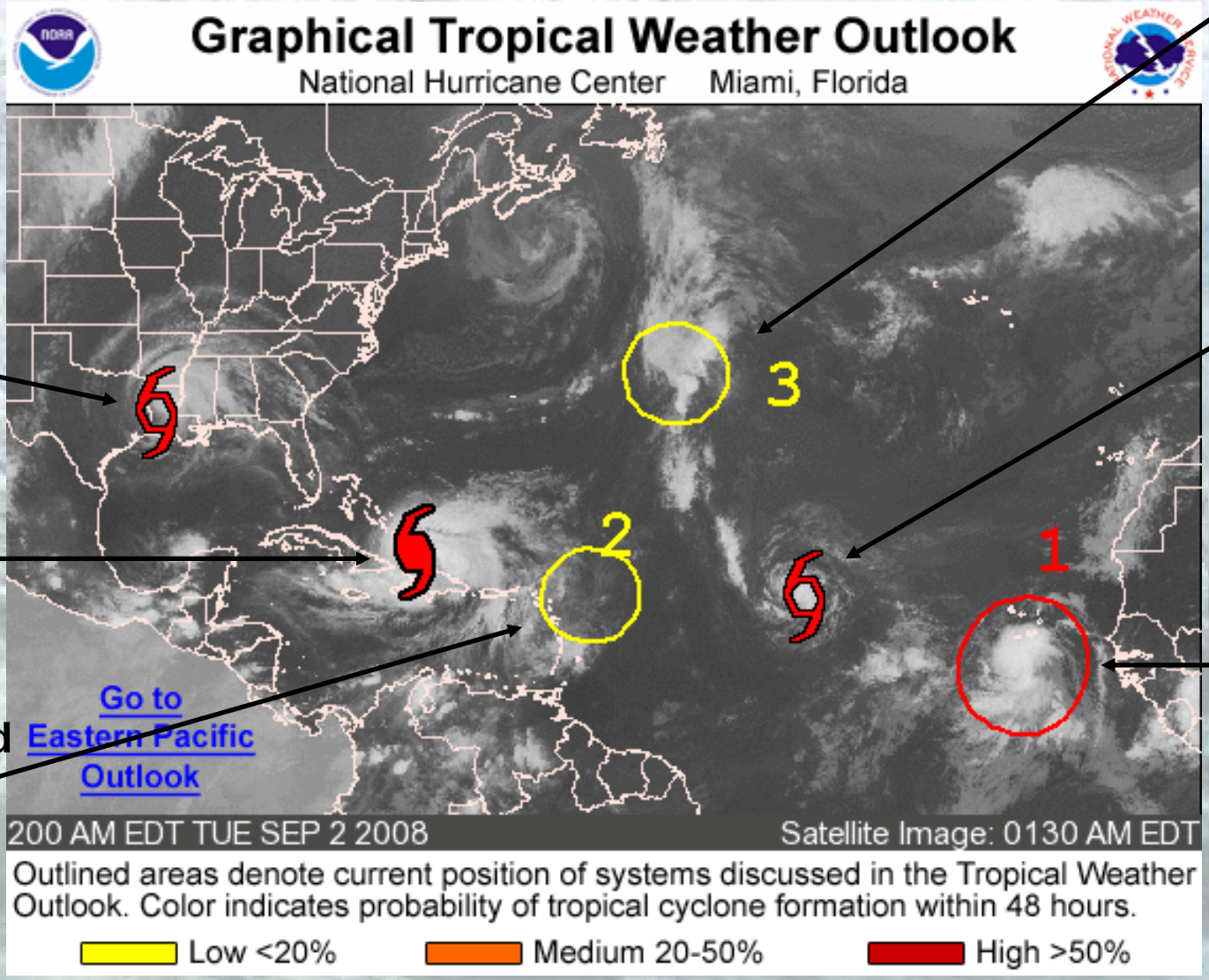

Atlantic TC CI Dvorak Fixes by Time Prior to Genesis
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
TC Amount
-120 -114 -108 -102 -96 -90 -84 -78 -72 -66 -60 -54 -48 -42 -36 -30 -24 -18 -12 -6 0
Time Prior to Genesis
<1
1
1.5
2
2.5
3
Fix Total
Fix Total >= 1
First Identified
First ID >=1


Cumulative Probability of Atlantic TC Genesis by CI Number (2001-2008)
Probability of Genesis
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
-120 -114 -108 -102 -96 -90 -84 -78 -72 -66 -60 -54 -48 -42 -36 -30 -24 -18 -12 -6 0
Time Prior to Genesis
Mean
< 1
1
1.5
2
2.5
3

Summary

- Classifications from various forecasters combined with best track analysis into *cyclogenesis dataset*
- Baseline statistical probabilities and climatology ***created*** for tropical cyclogenesis in Atlantic, East and Central Pacific
  - Relationship between Dvorak Number, Genesis Frequency, and Time Prior to Genesis
- May be used as a benchmark to weigh anomalous risk of potential TC genesis cases

Sample Probabilities



Undeveloped

No fix

Gustav

Ike

Hanna

Josephine

65%

2.0 CI

Undeveloped

19%

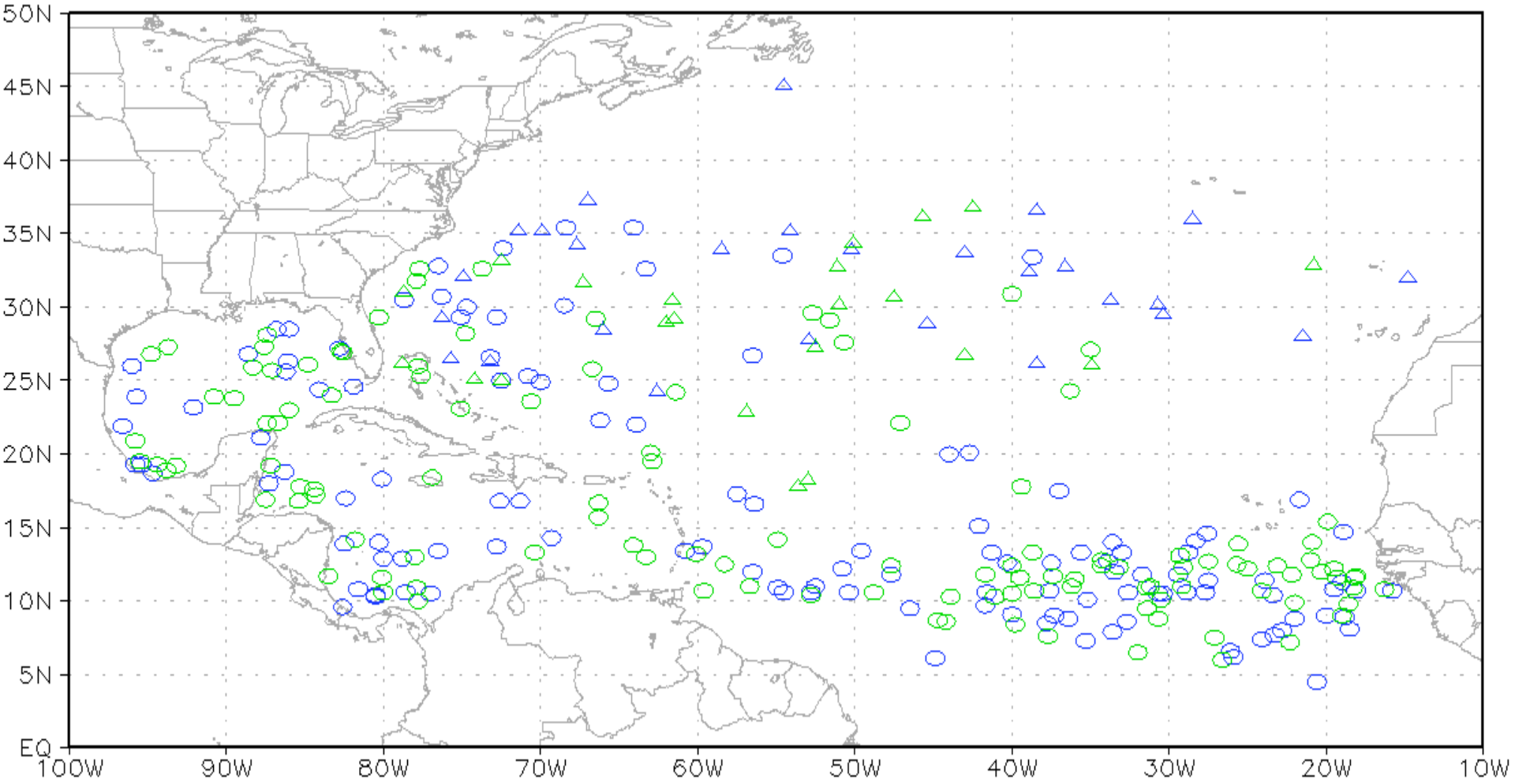
TWTC

Current and Future (Potential) Work

- Add 2009 fixes to database
  - AL, EP acquired and formatted
  - Verify 2001-2008 probabilities
  - Compare with NHC/CPHC experimental product
- Spatial/Temporal cyclogenesis probabilities
  - By Month, Year
  - By Latitude, Longitude

- Expand dataset back in time (digitize fixes)
- Analysis of SAB, JTWC, JMA, others
- Relate to model cyclogenesis
  - Compare to analog events, dynamical factors

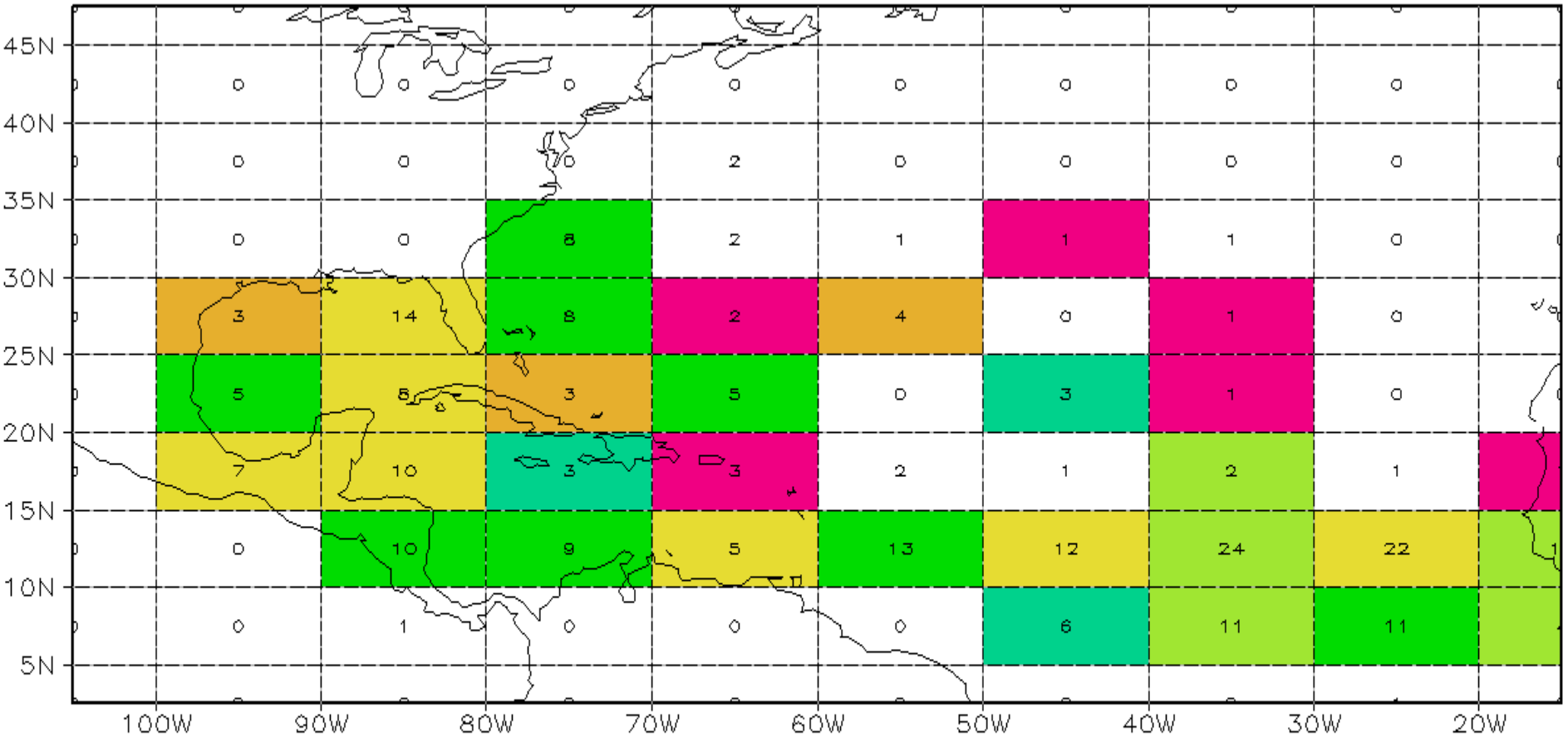
ALL Inital Dvorak Fixes (2001–2008)



Green=TC
Circle=Tropical

Blue=Non-Developing
Triangle=SubTropical

TC Development Rate (no ST) 2001–2008



Total TC and disturbance count
Based on Lat/Lon of initial Dvorak fix

Acknowledgements

NOAA Hollings Scholarship

FSU/COAPS

Rick Knabb

Staff at NWS WFO Honolulu

Dan Brown

Bob Hart

Mark Bourassa

Mark Powell

Shawn Smith

Jacob Rettig

Ben Schenkel

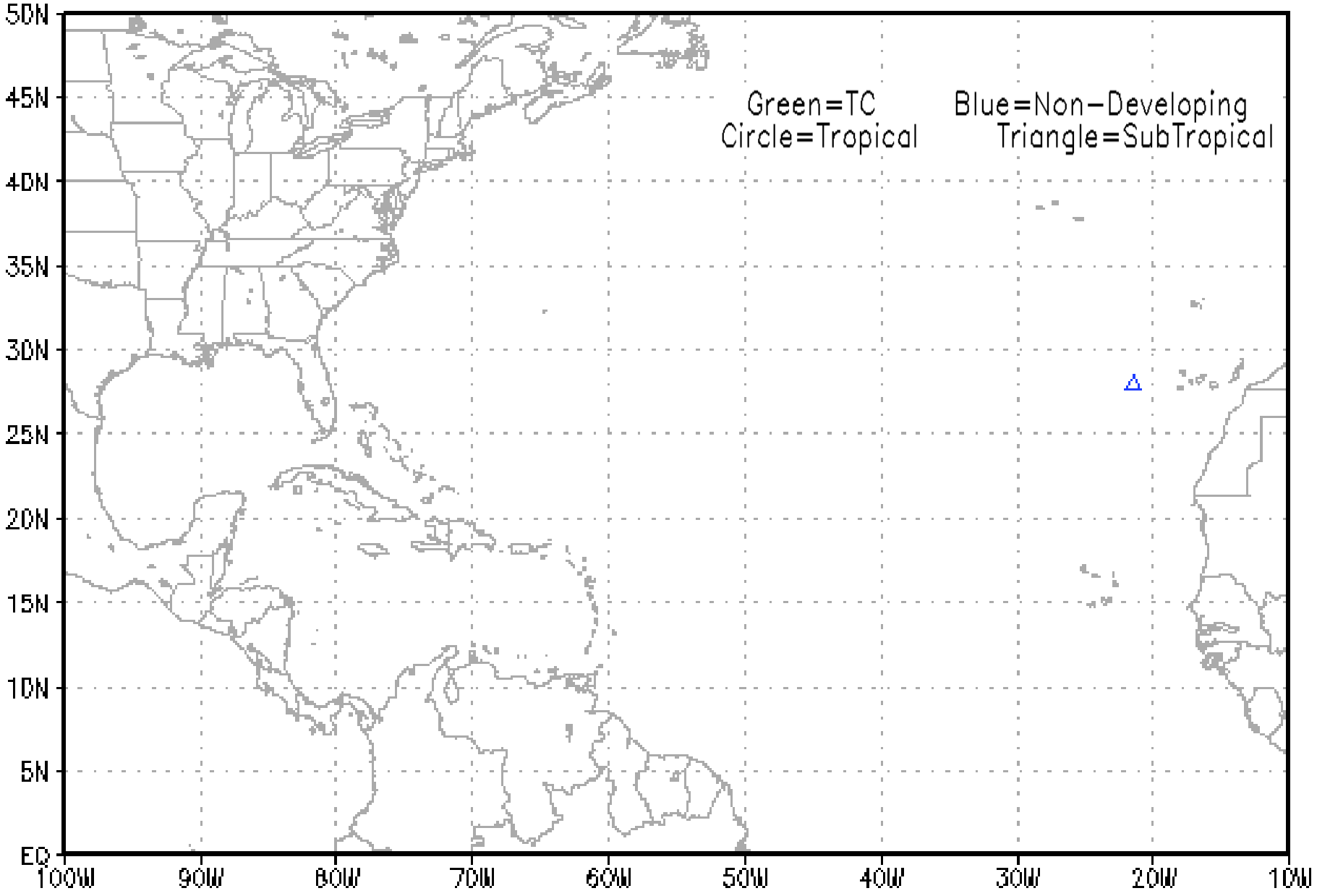
Initial Dvorak Fix Locations Atlantic (2001-2008)

MONTHLY

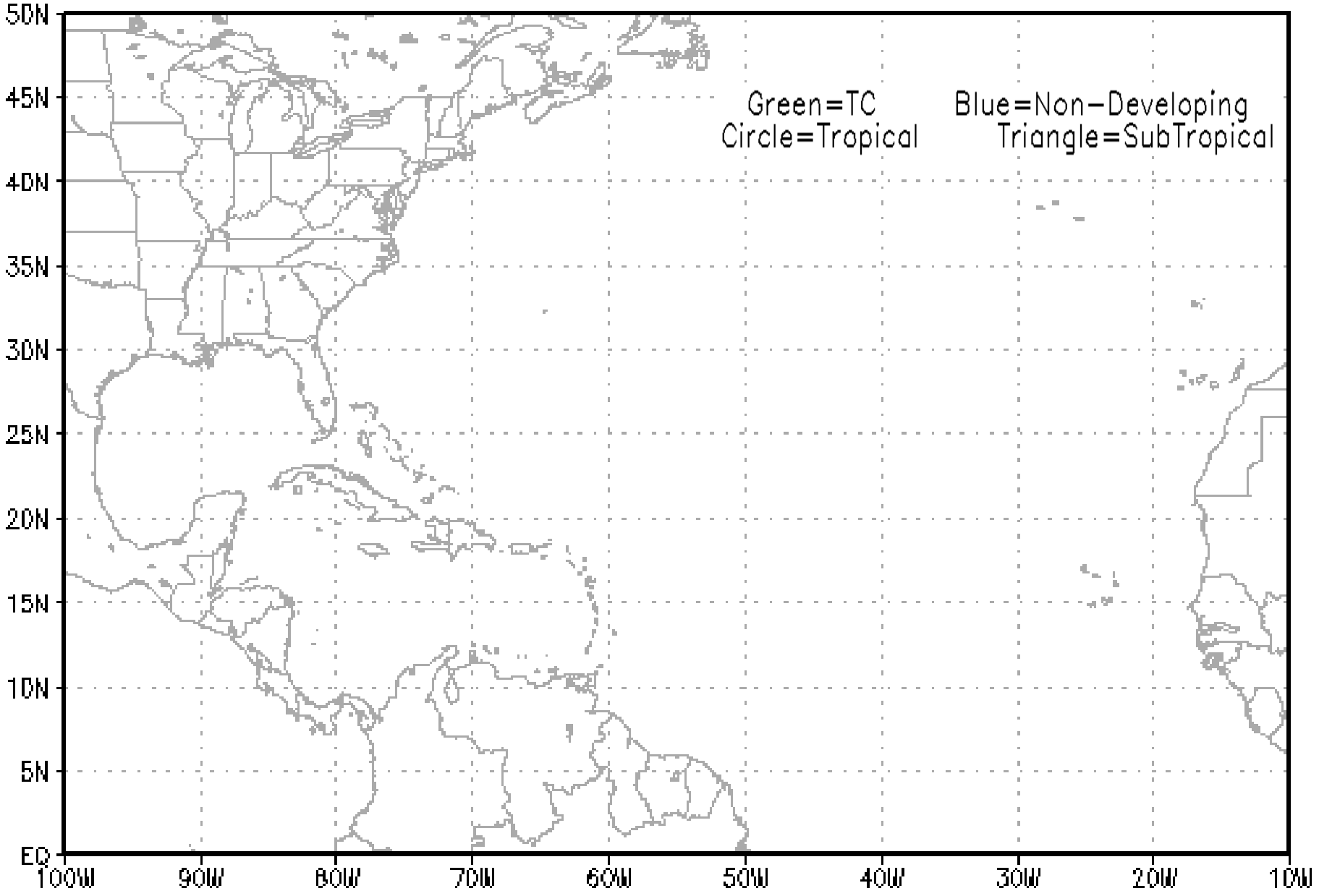
Legend

Circle.....	Incipient systems with only tropical Dvorak classifications
Triangle.....	Systems with at least one ST fix during incipient stage
Green…….	Developed into a tropical cyclone (“pre-genesis”)
Blue……	Did not develop into a tropical cyclone (“non-genesis”)

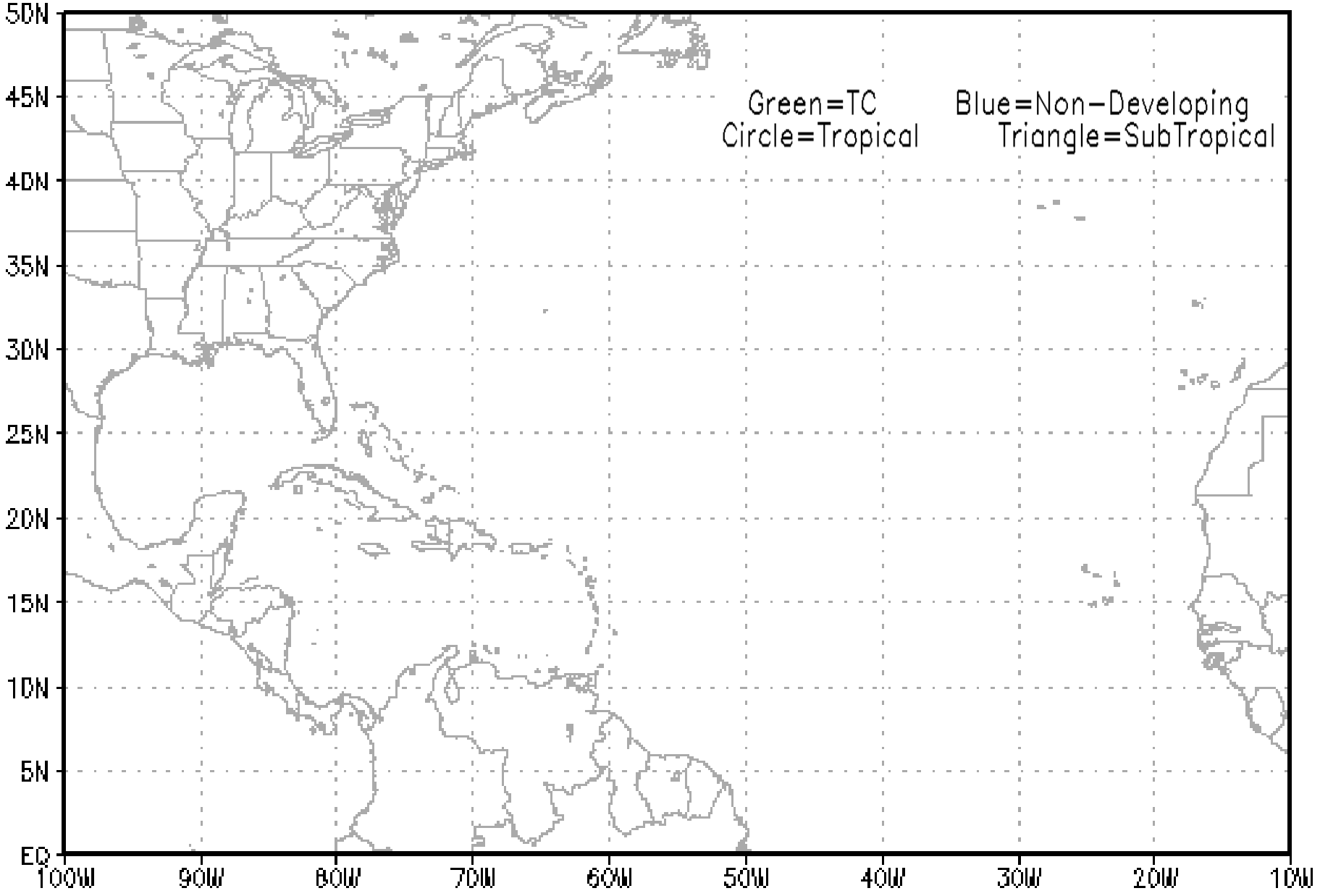
January Initial Dvorak Fixes (2001–2008)



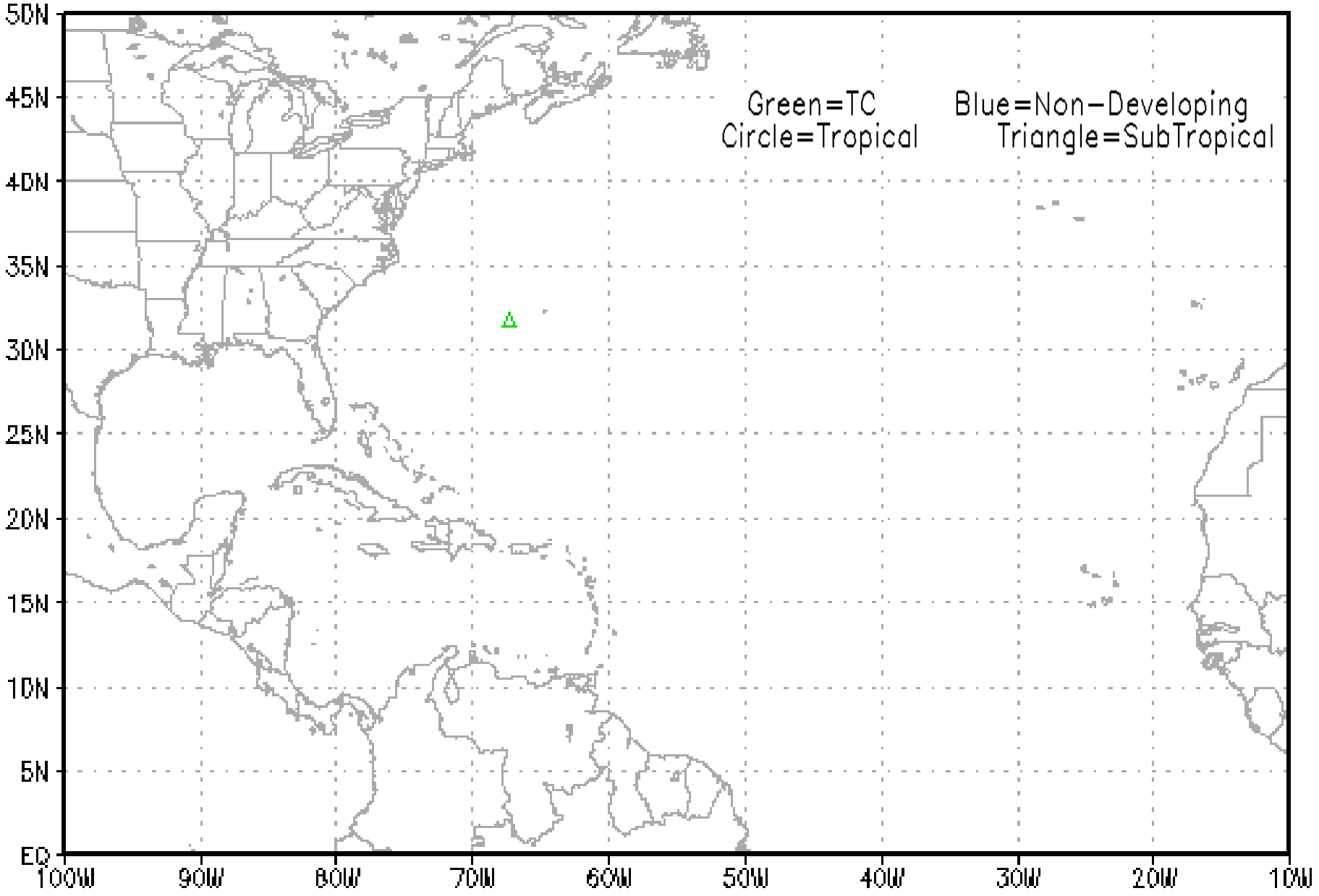
February Initial Dvorak Fixes (2001–2008)



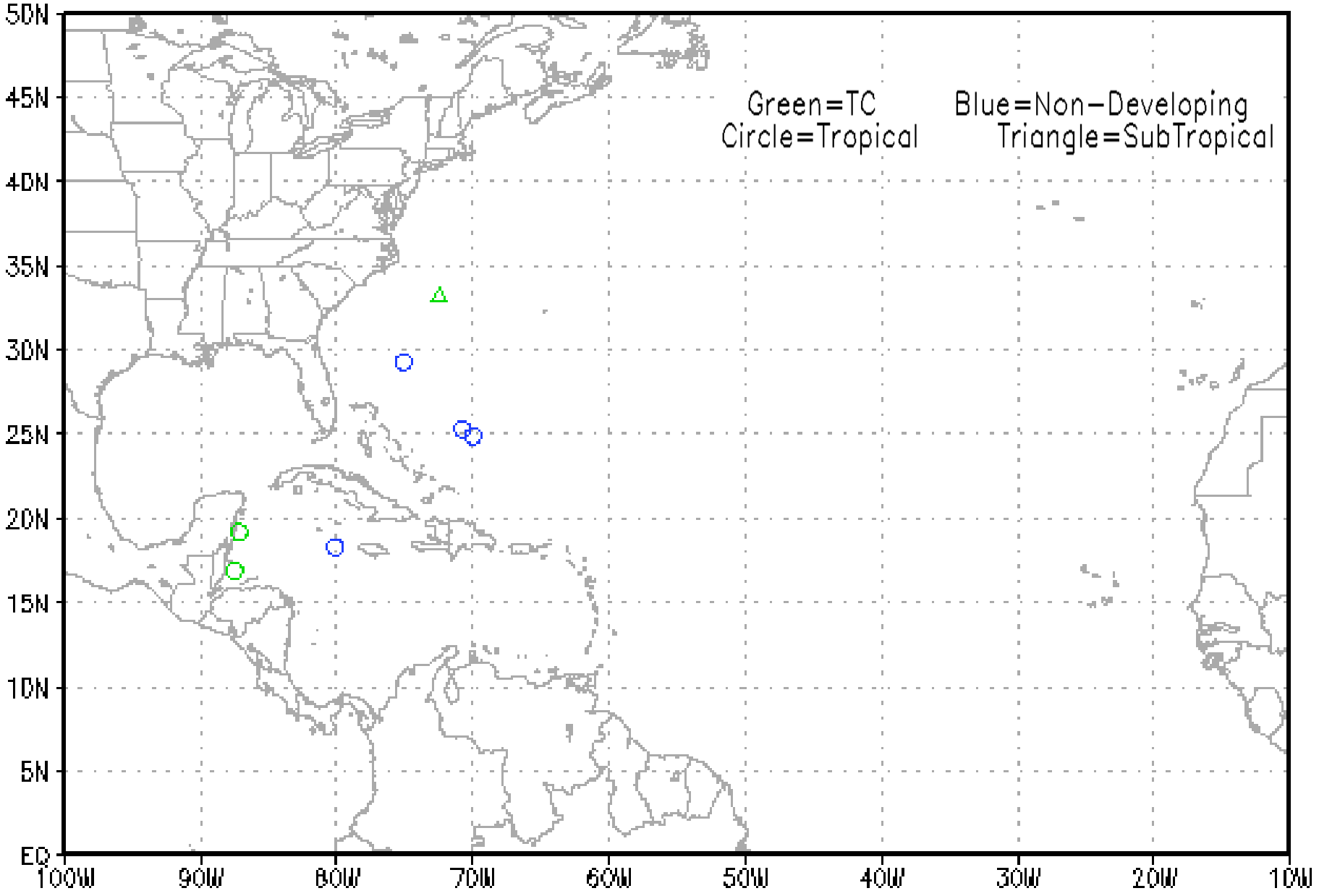
March Initial Dvorak Fixes (2001–2008)



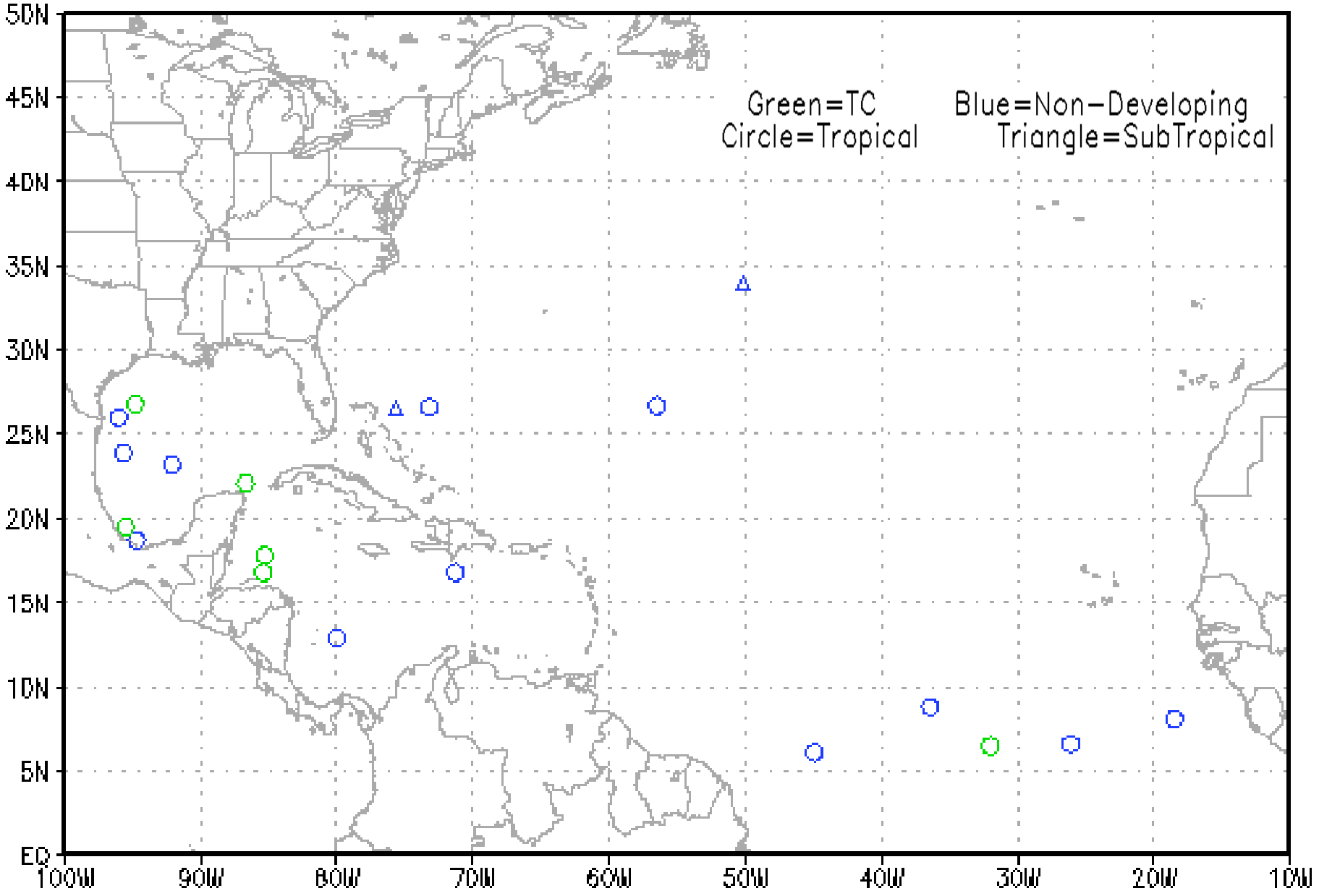
April Initial Dvorak Fixes (2001-2008)



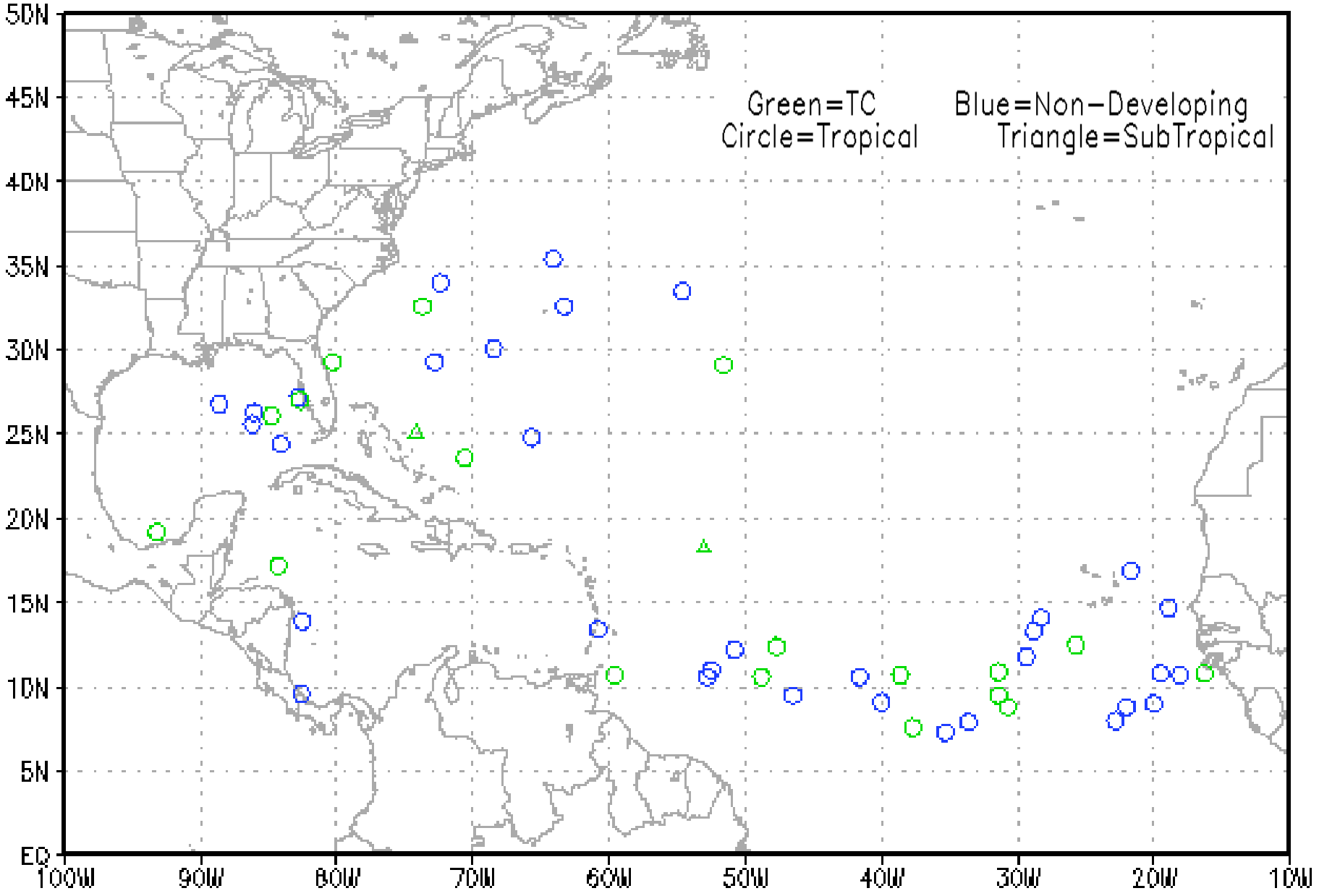
May Initial Dvorak Fixes (2001–2008)



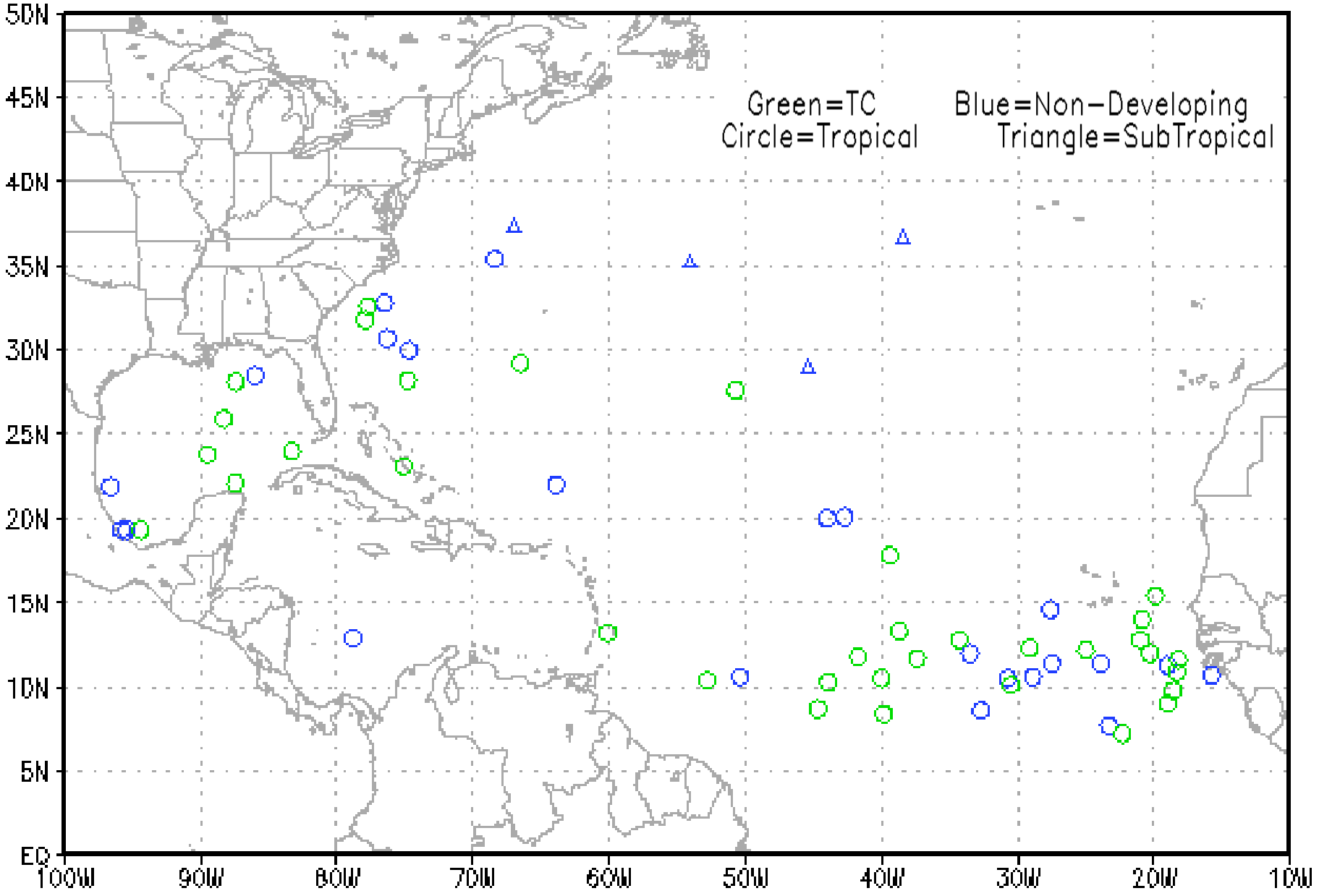
June Initial Dvorak Fixes (2001-2008)



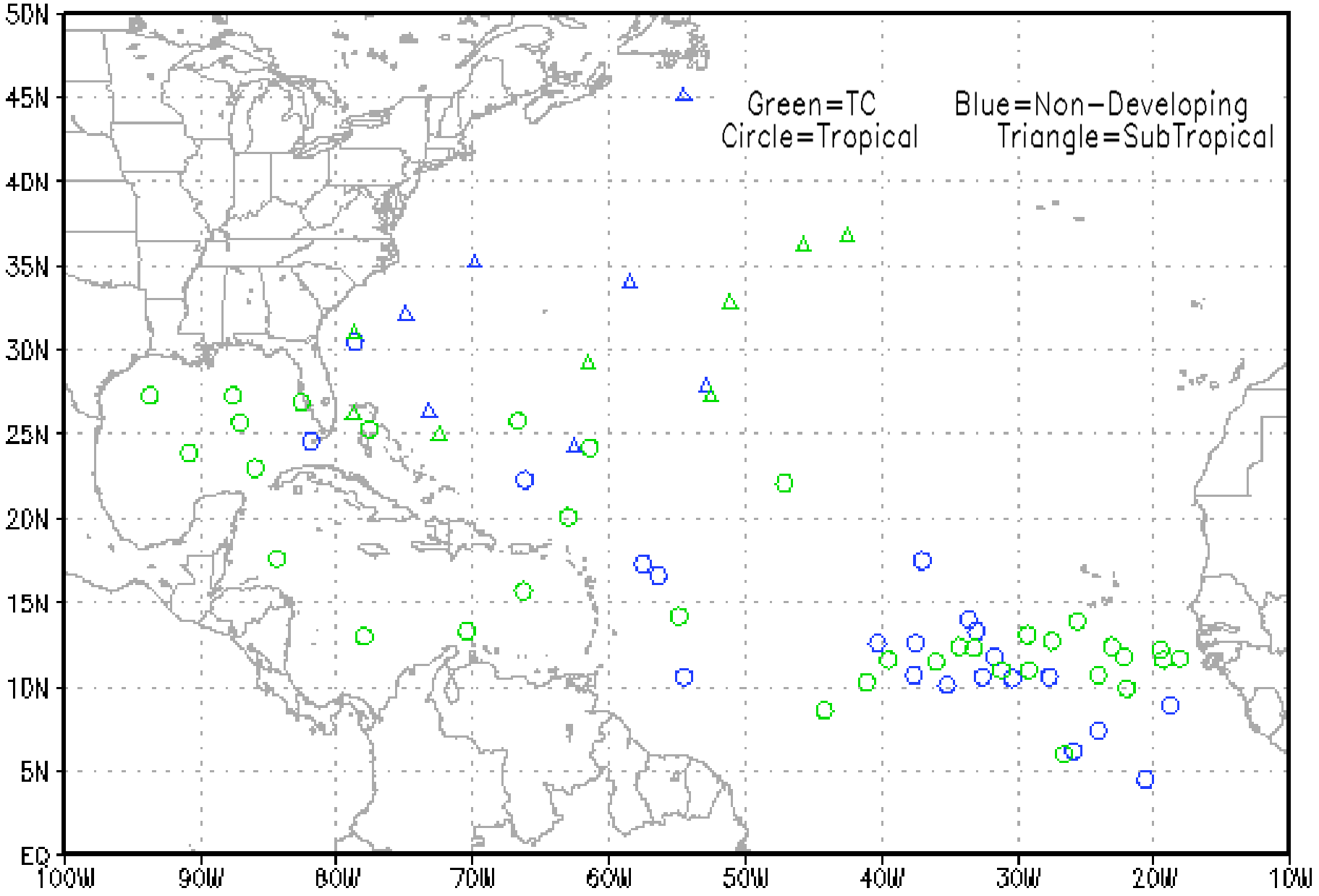
July Initial Dvorak Fixes (2001–2008)



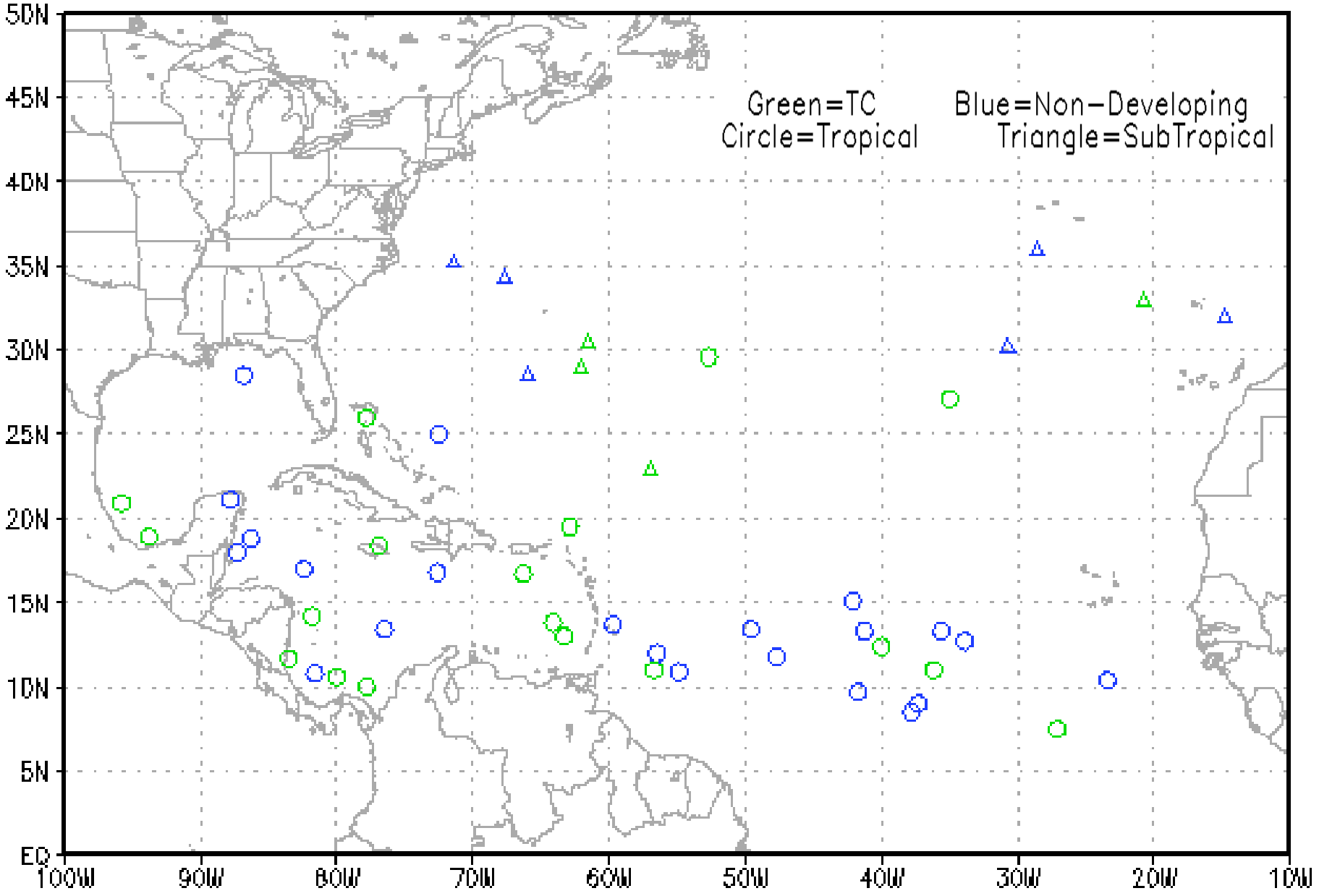
August Initial Dvorak Fixes (2001–2008)



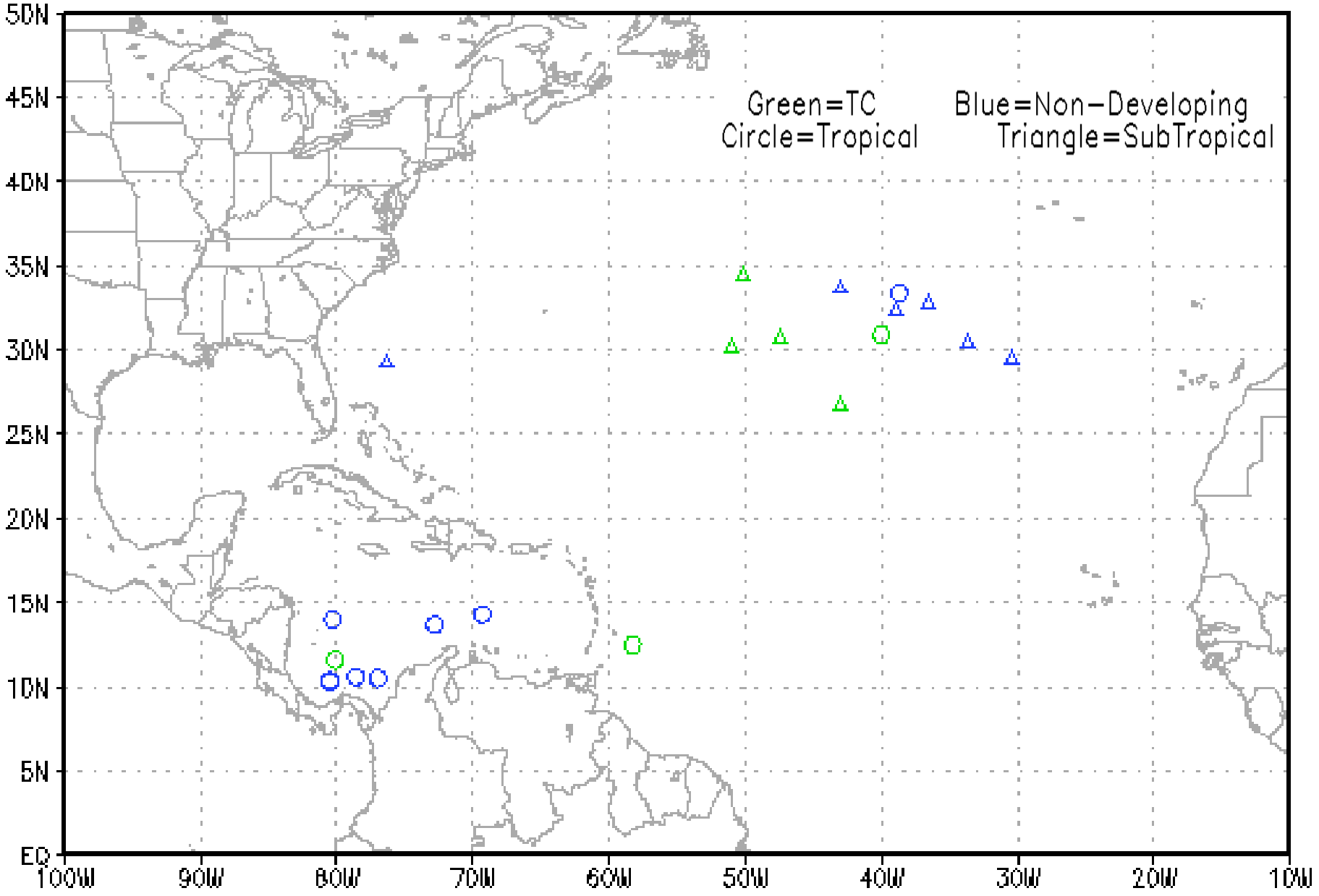
September Initial Dvorak Fixes (2001-2008)



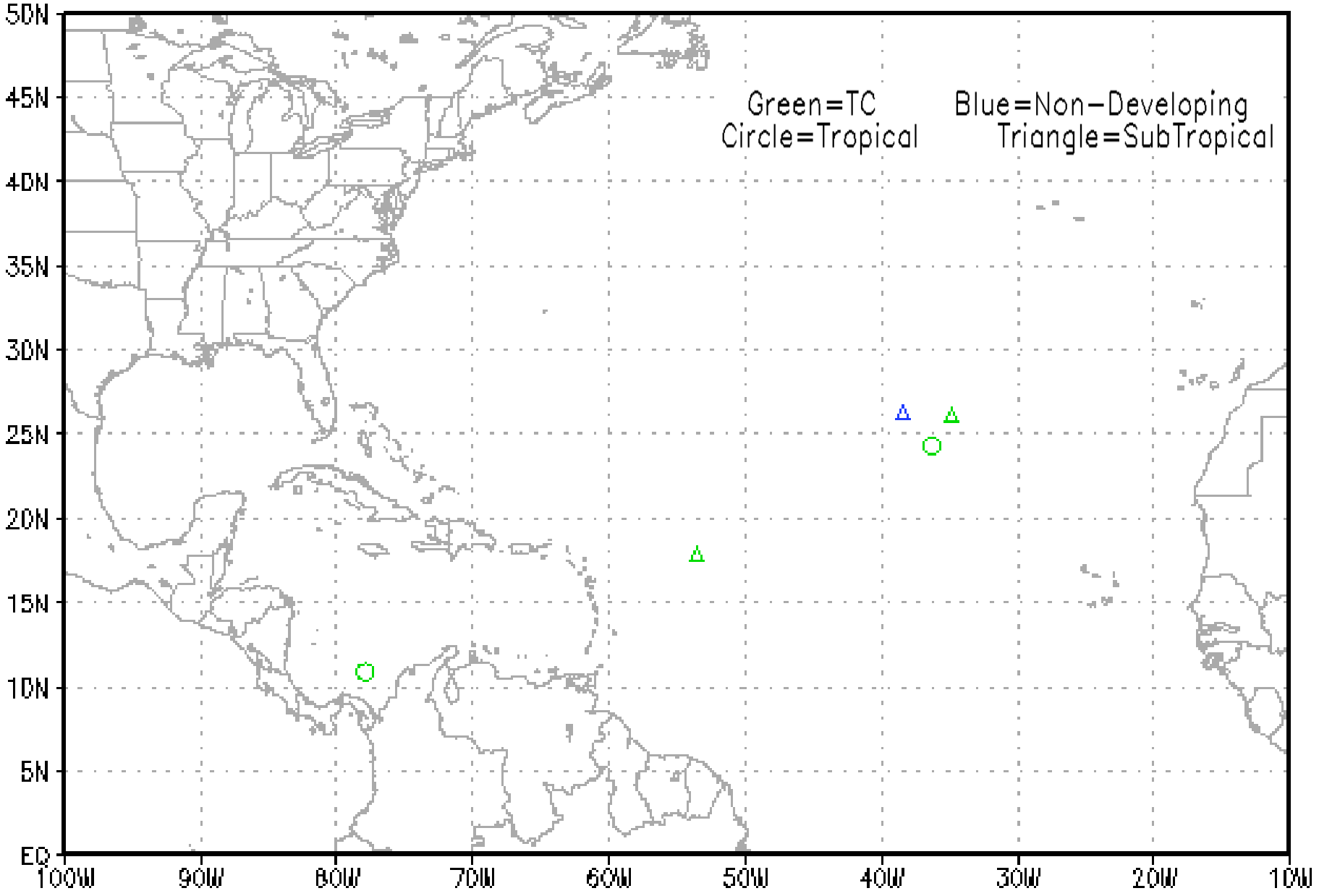
October Initial Dvorak Fixes (2001–2008)



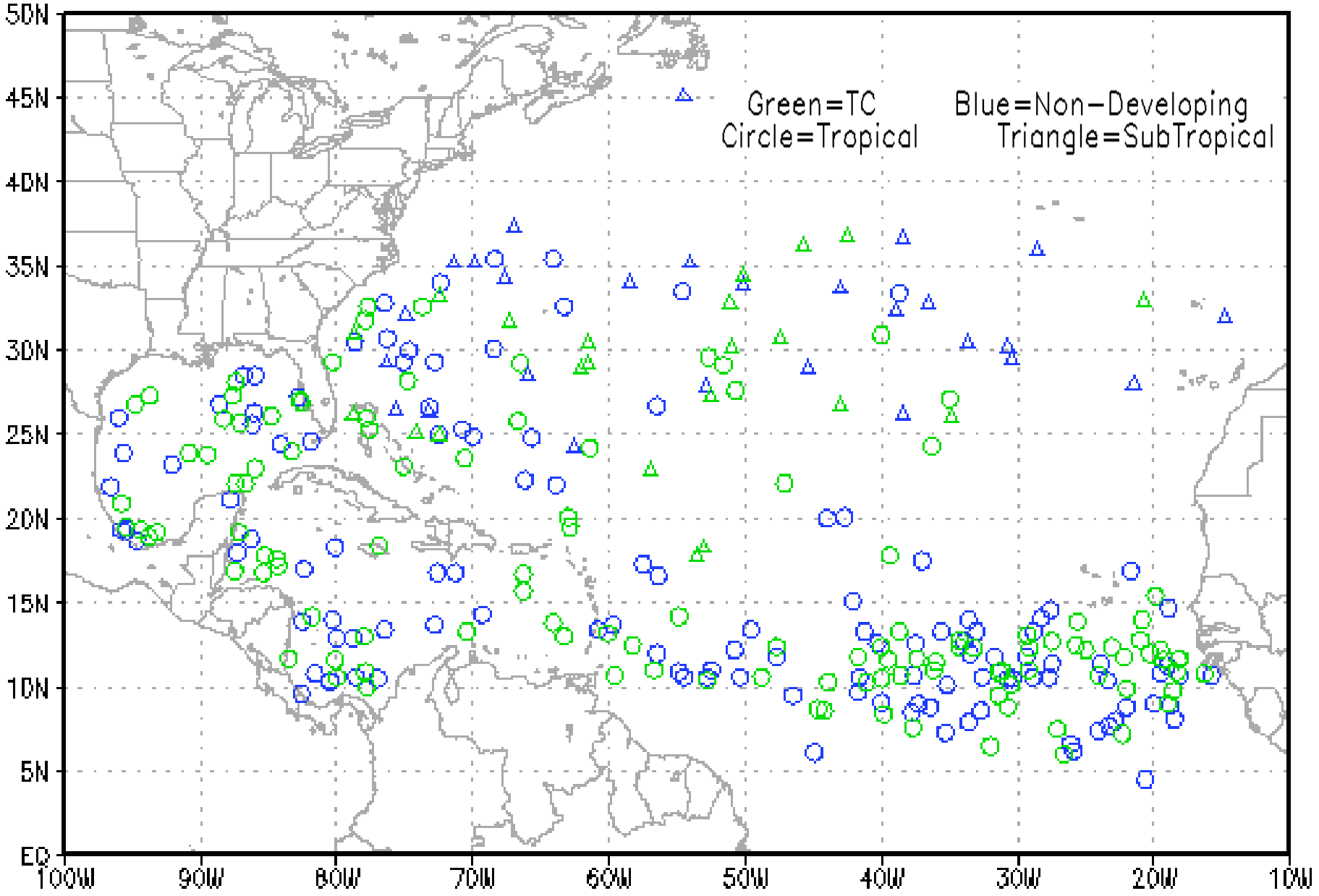
November Initial Dvorak Fixes (2001-2008)



December Initial Dvorak Fixes (2001-2008)



ALL Inital Dvorak Fixes (2001-2008)



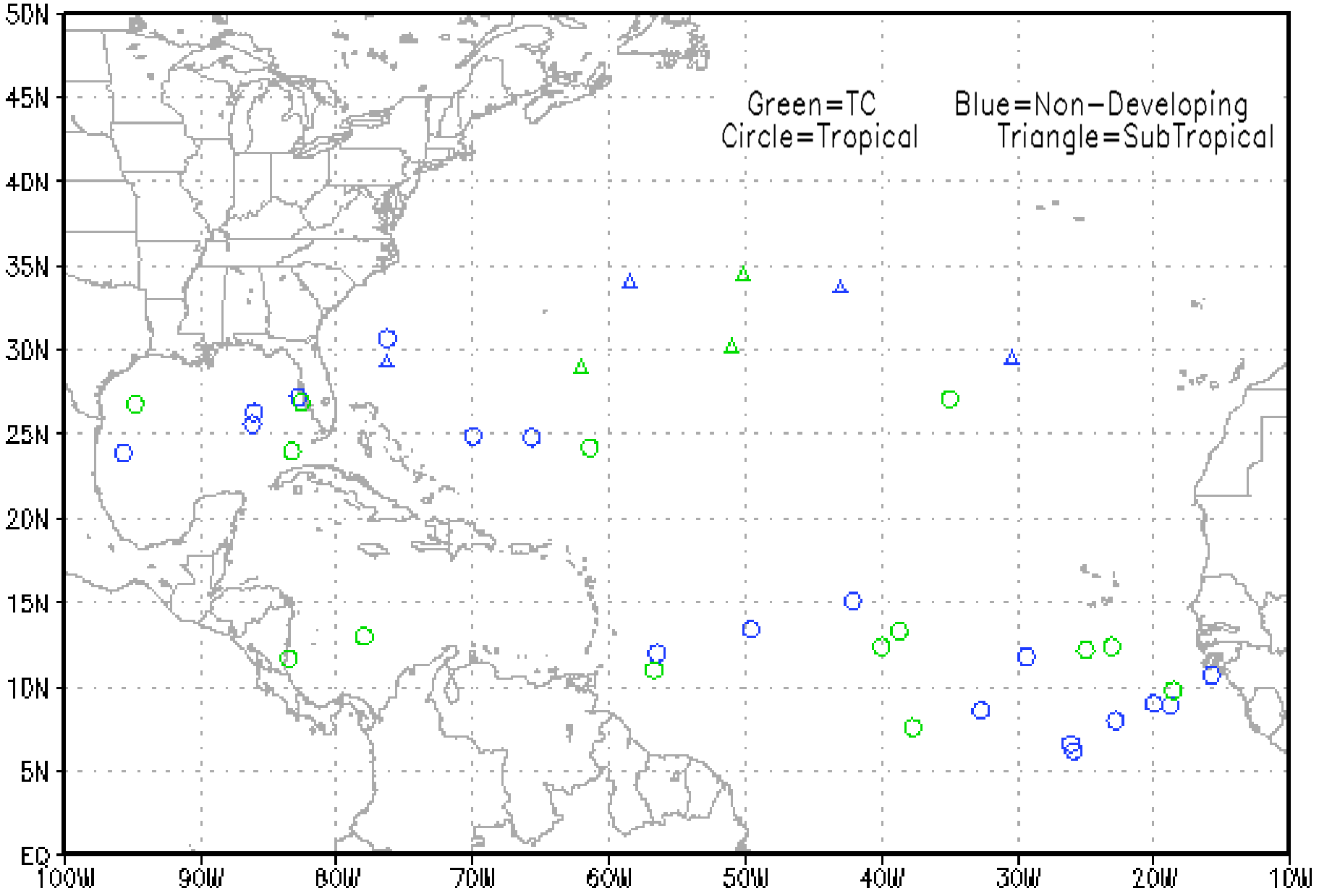
Initial Dvorak Fix Locations Atlantic (2001-2008)

YEARLY

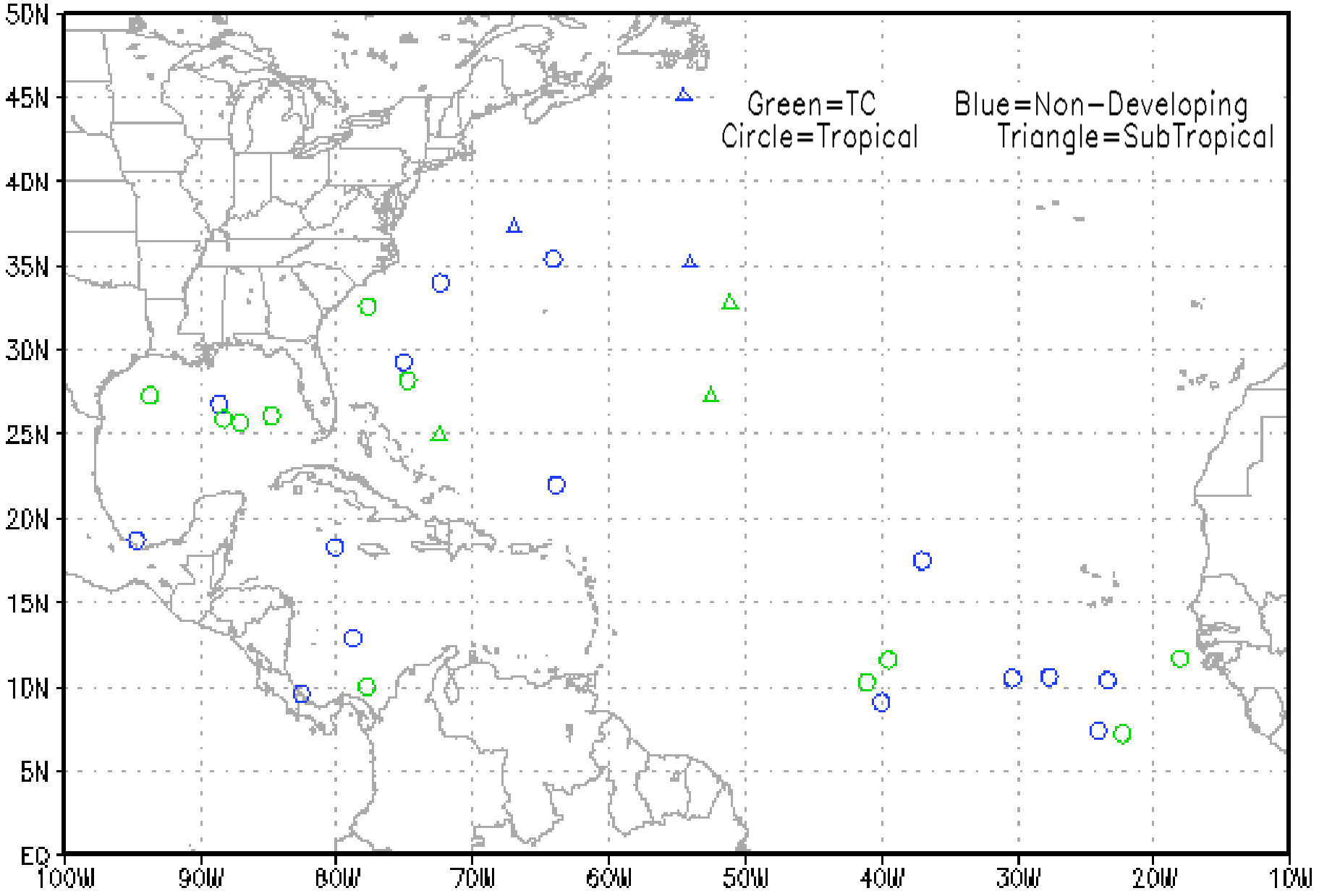
Legend

Circle.....	Incipient systems with only tropical Dvorak classifications
Triangle.....	Systems with at least one ST fix during incipient stage
Green…….	Developed into a tropical cyclone (“pre-genesis”)
Blue……	Did not develop into a tropical cyclone (“non-genesis”)

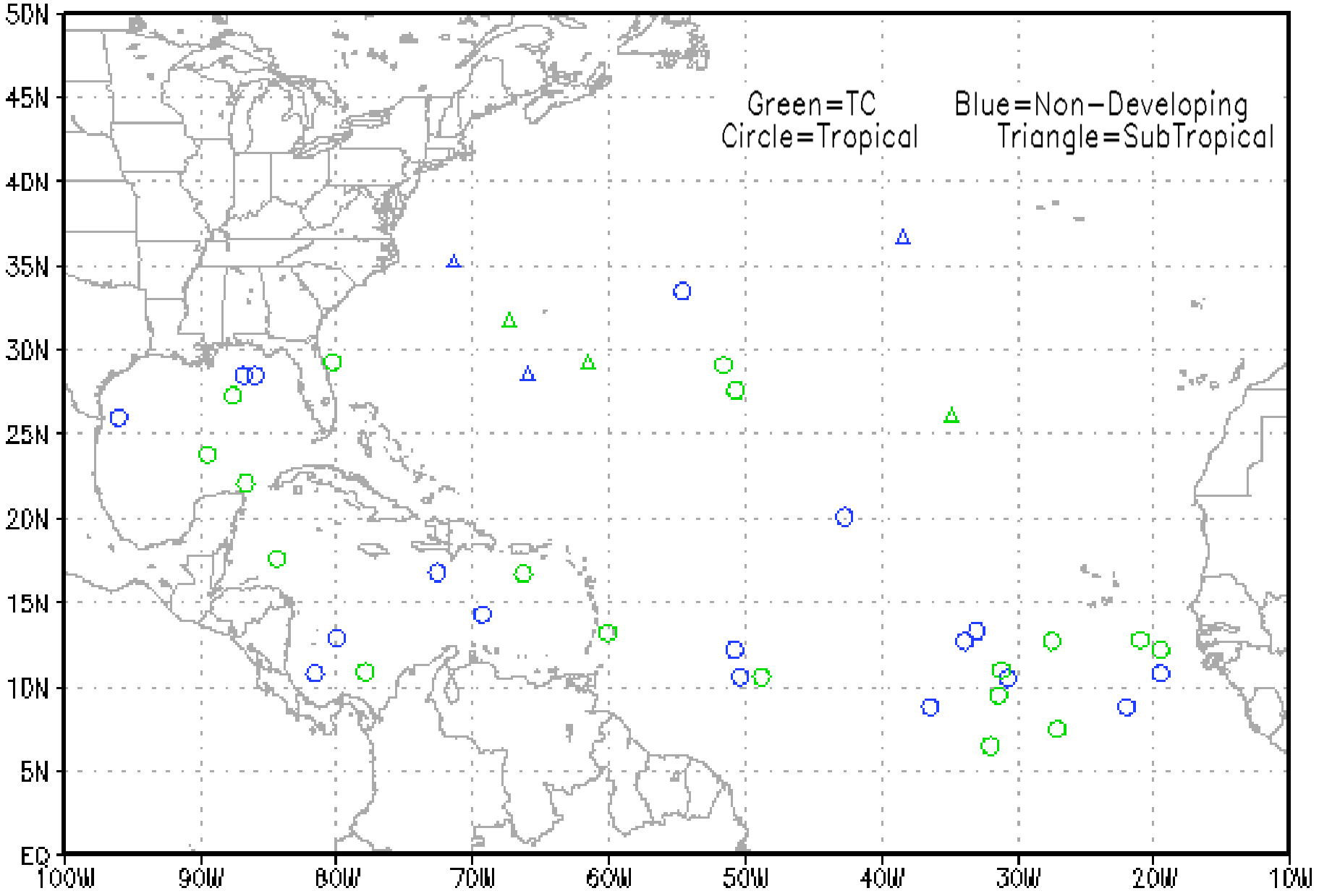
Initial Dvorak Fixes (2001)



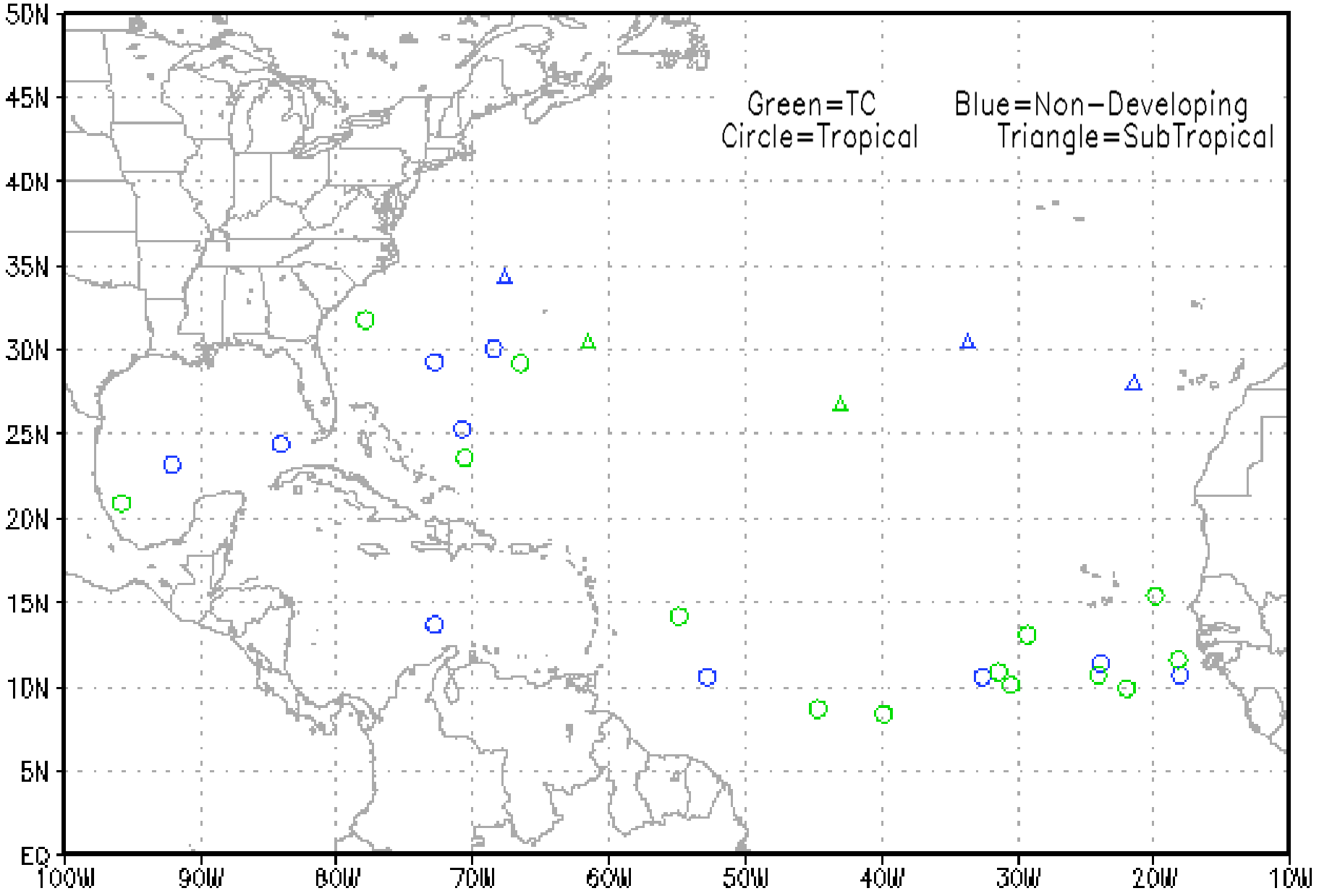
Initial Dvorak Fixes (2002)



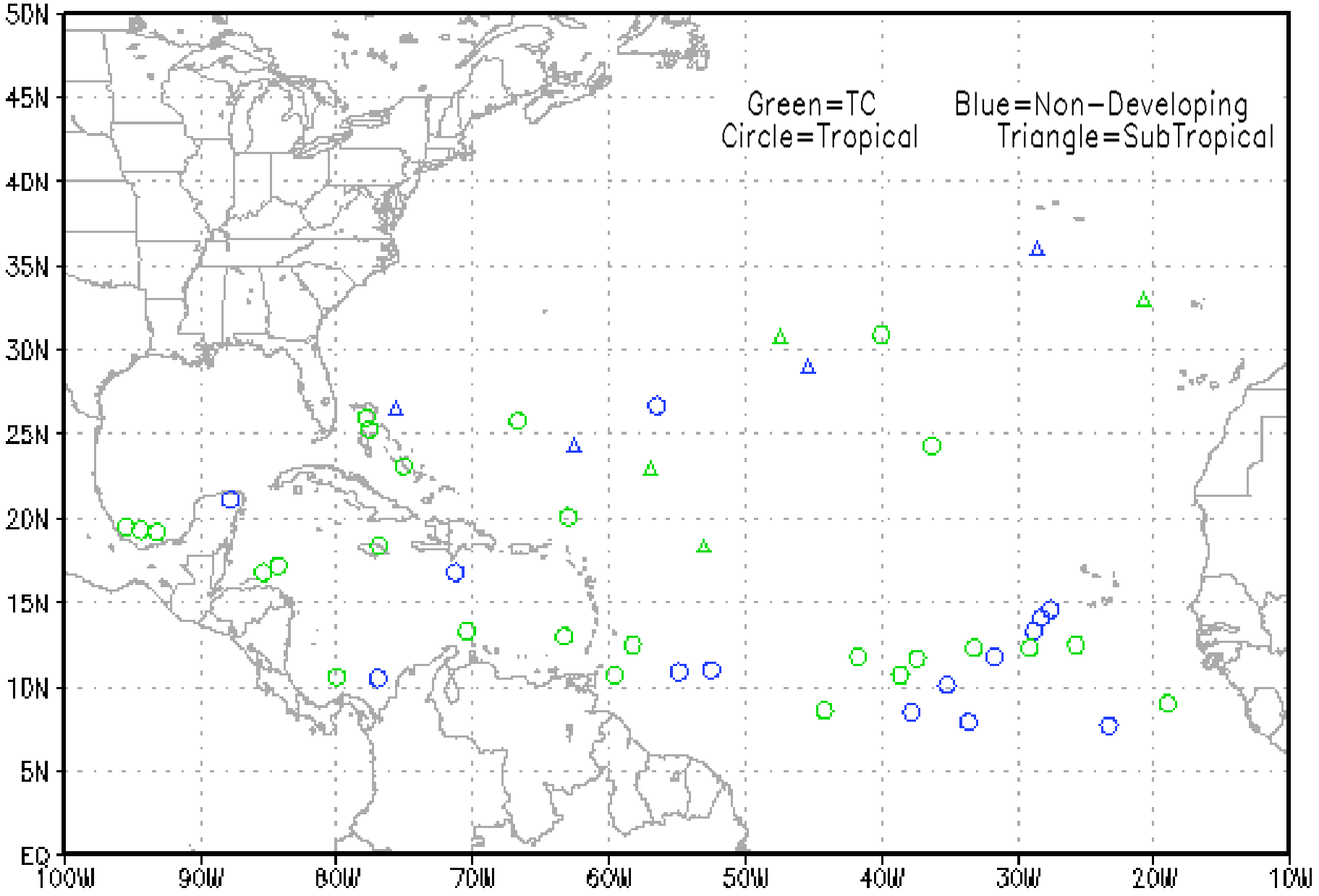
Initial Dvorak Fixes (2003)



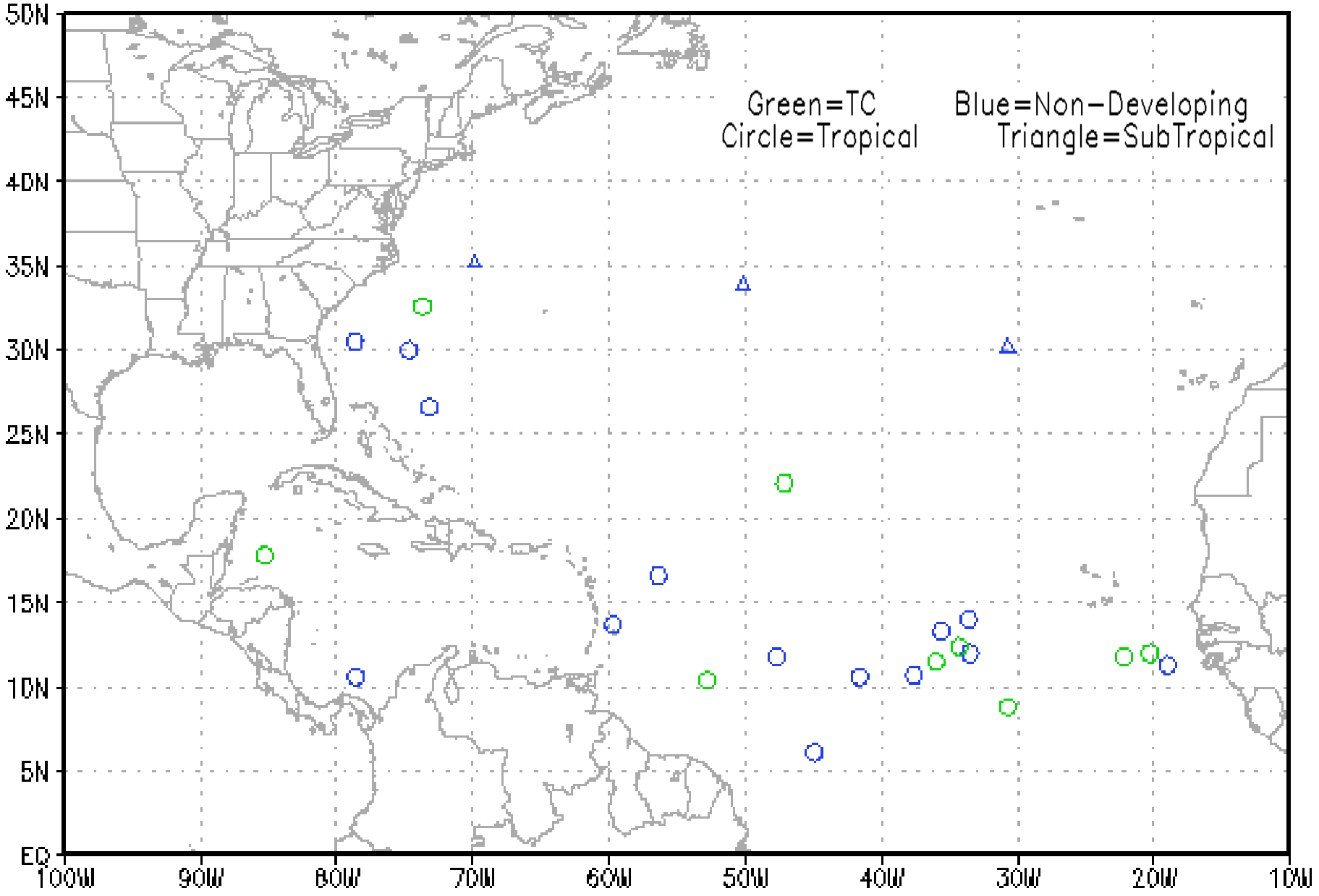
Initial Dvorak Fixes (2004)



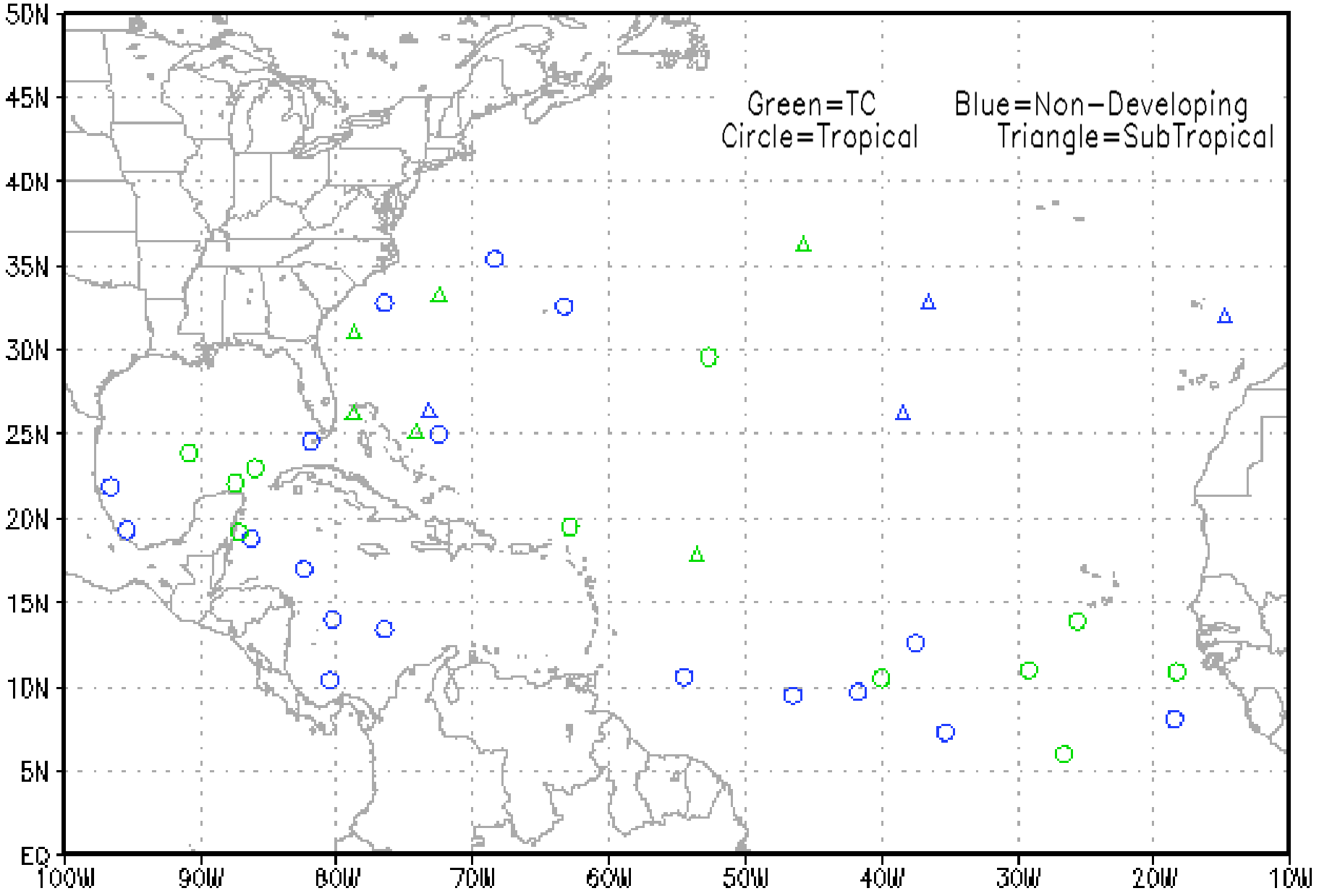
Initial Dvorak Fixes (2005)



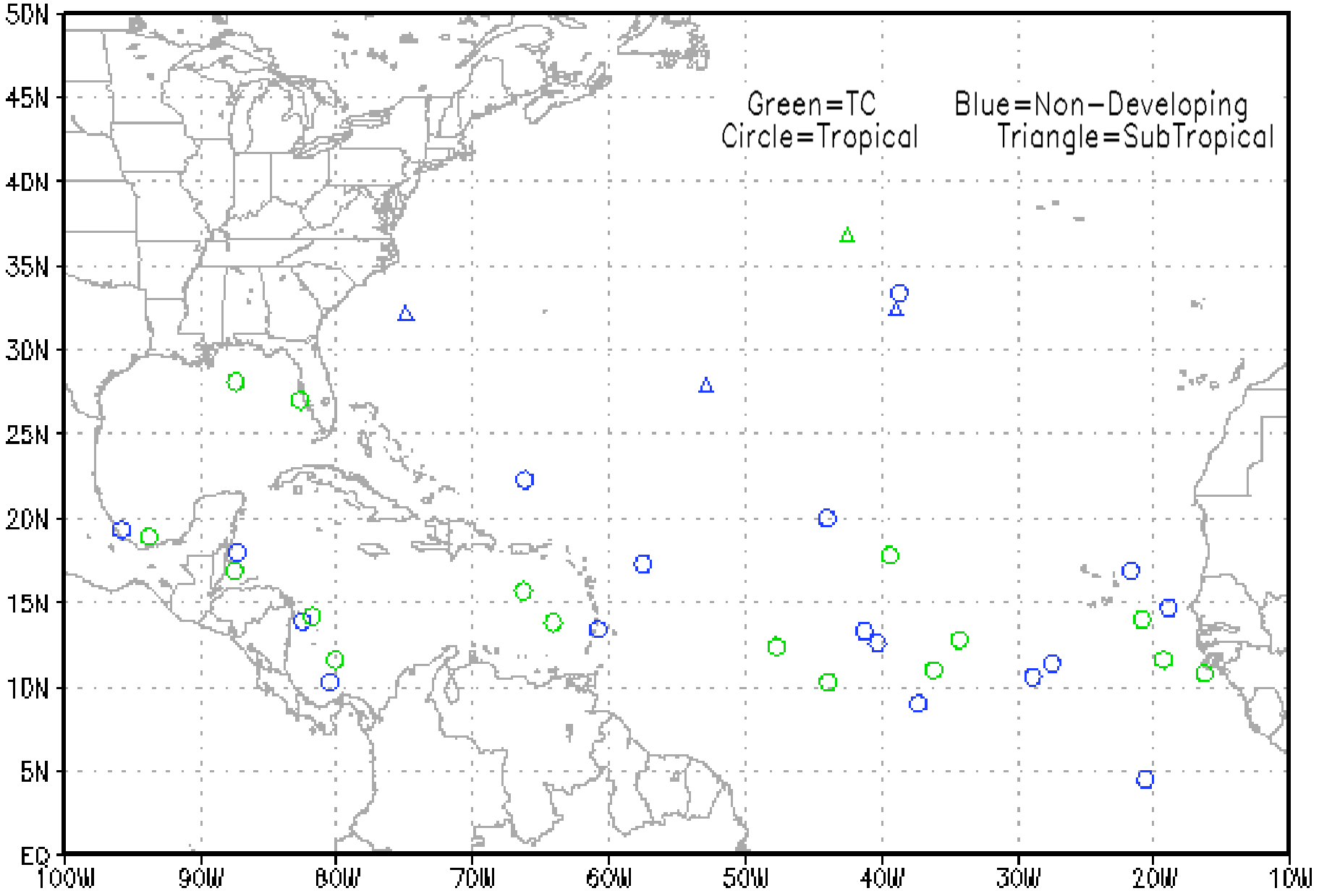
Initial Dvorak Fixes (2006)



Initial Dvorak Fixes (2007)



Initial Dvorak Fixes (2008)



ALL Inital Dvorak Fixes (2001-2008)