Compiling new TC climatologies and their use towards forecast improvements

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Motivation

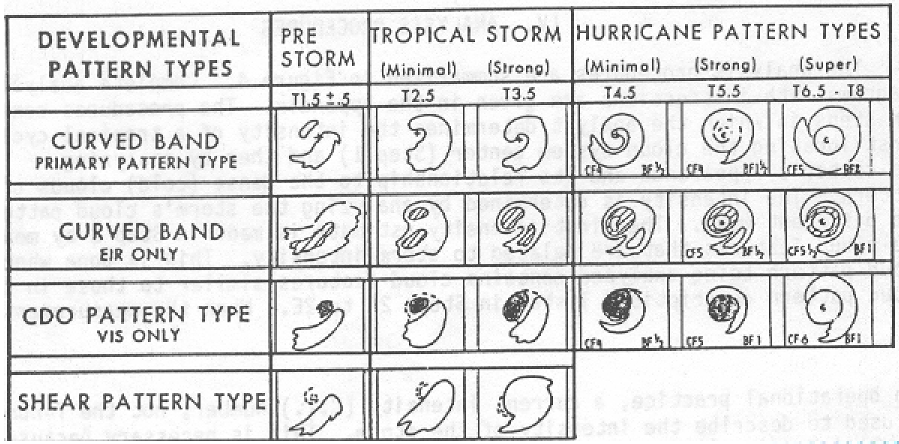
- Lack of genesis guidance
  - There has been no objective, disturbance-based genesis metric available to forecasters..
    - In general, numerical models have difficulty in establishing and forecasting pre-genesis waves.
  - Absence of invests/tropical disturbances database.
- Scarcity of inner-core observations in TCs
  - Recon is extremely useful, but limited.
  - Previous efforts have mostly focused on the impact of the environment surrounding the TC.
- The following presentation will show our efforts to solve these problems.

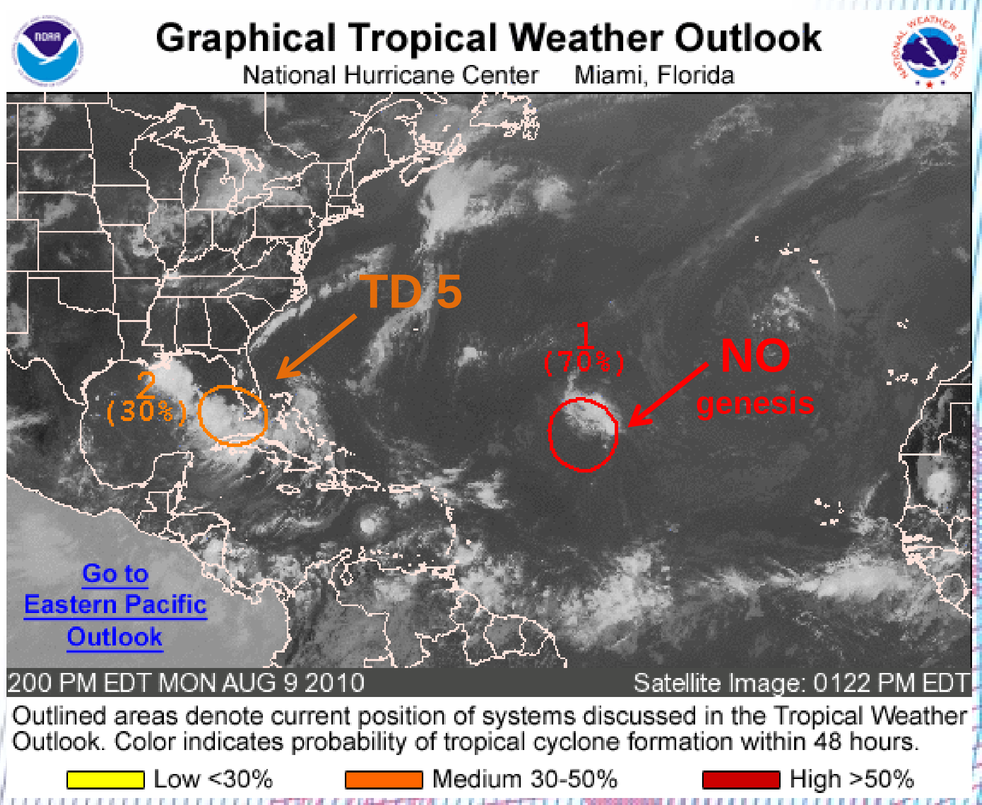
Outline

- TC genesis probabilities using Dvorak analysis
  - Climatology of pre-genesis Dvorak fixes
  - Probabilities of genesis using TAFB and SAB
  - Verification and real-time testing
- Objectively quantifying TC core and structure
  - Recon, HURSAT, and ARCHER
  - Climatology of eye-size and TC intensity
  - Further satellite analyses

An Objective Climatological TC Genesis Forecast

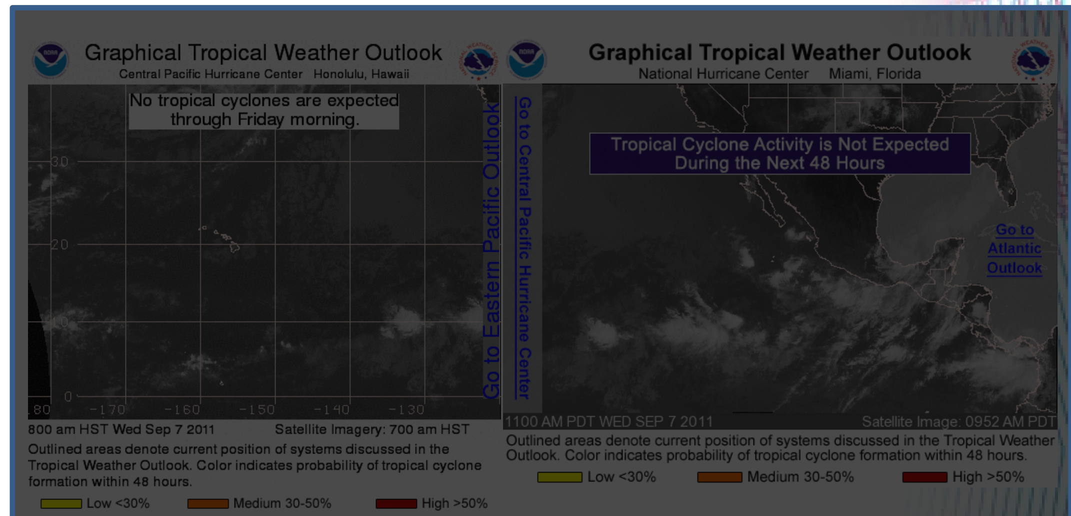
- Dvorak analysis provides position and intensity estimates, even for tropical disturbances and waves
- Past Dvorak analysis data gathered from:
  - pre-genesis TCs
  - non-developing invests
  - non-invest disturbances (where available)
- Historical rates of genesis (based on Dvorak intensity numbers) can be used to help inform current risk of genesis

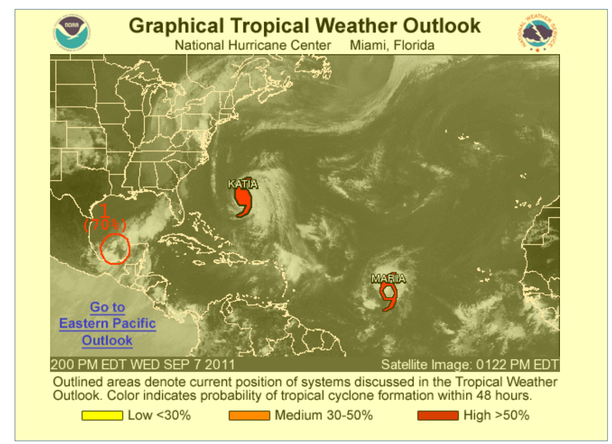




Scope of Climatology

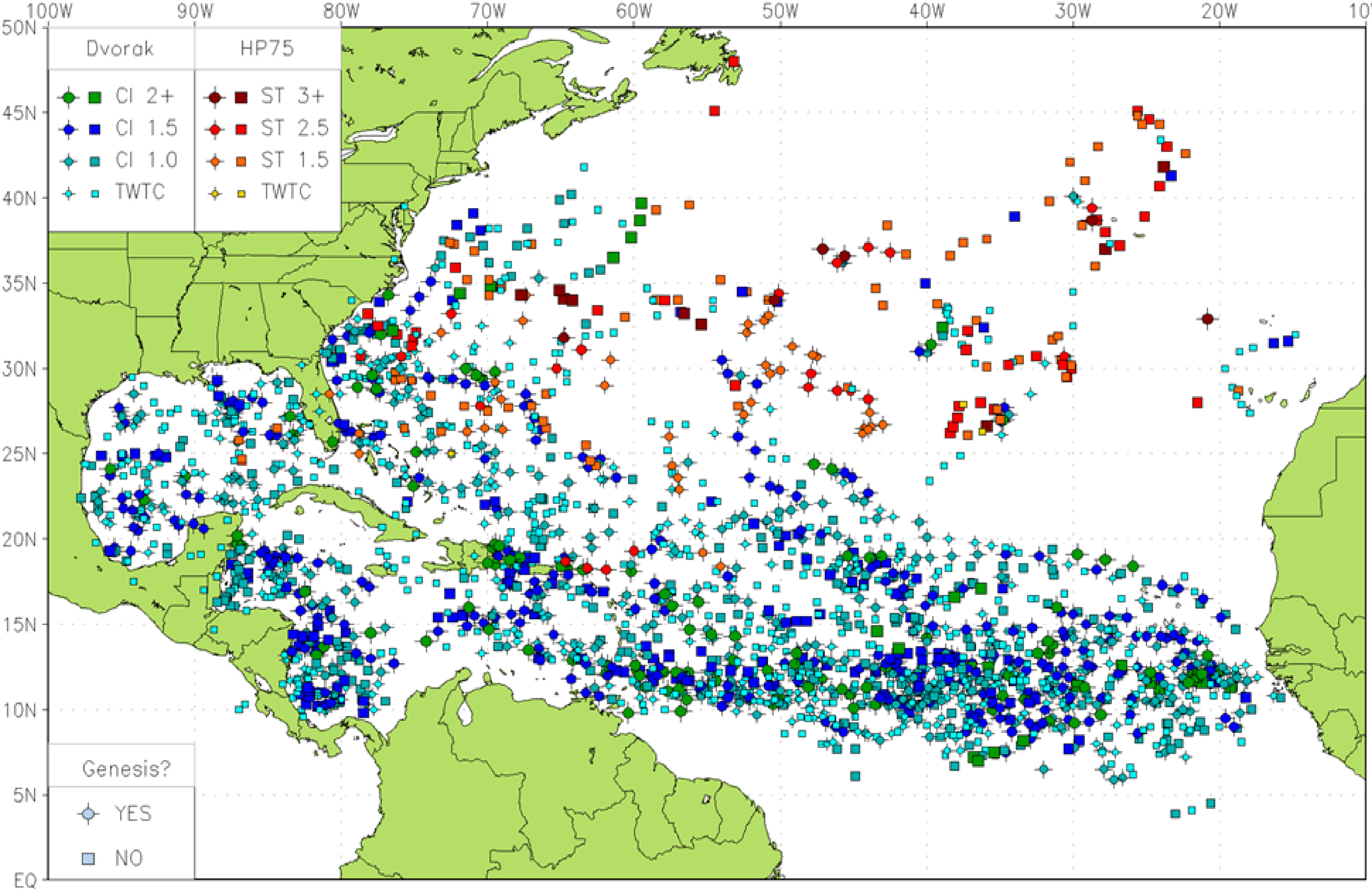
- Current data includes:
  - TAFB
    - Atlantic and east Pacific basins
    - 2001-2010
  - CPHC
    - Central Pacific basin
    - 2001-2008
  - SAB
    - Worldwide
    - 2007-2010 (Atlantic since 2005)

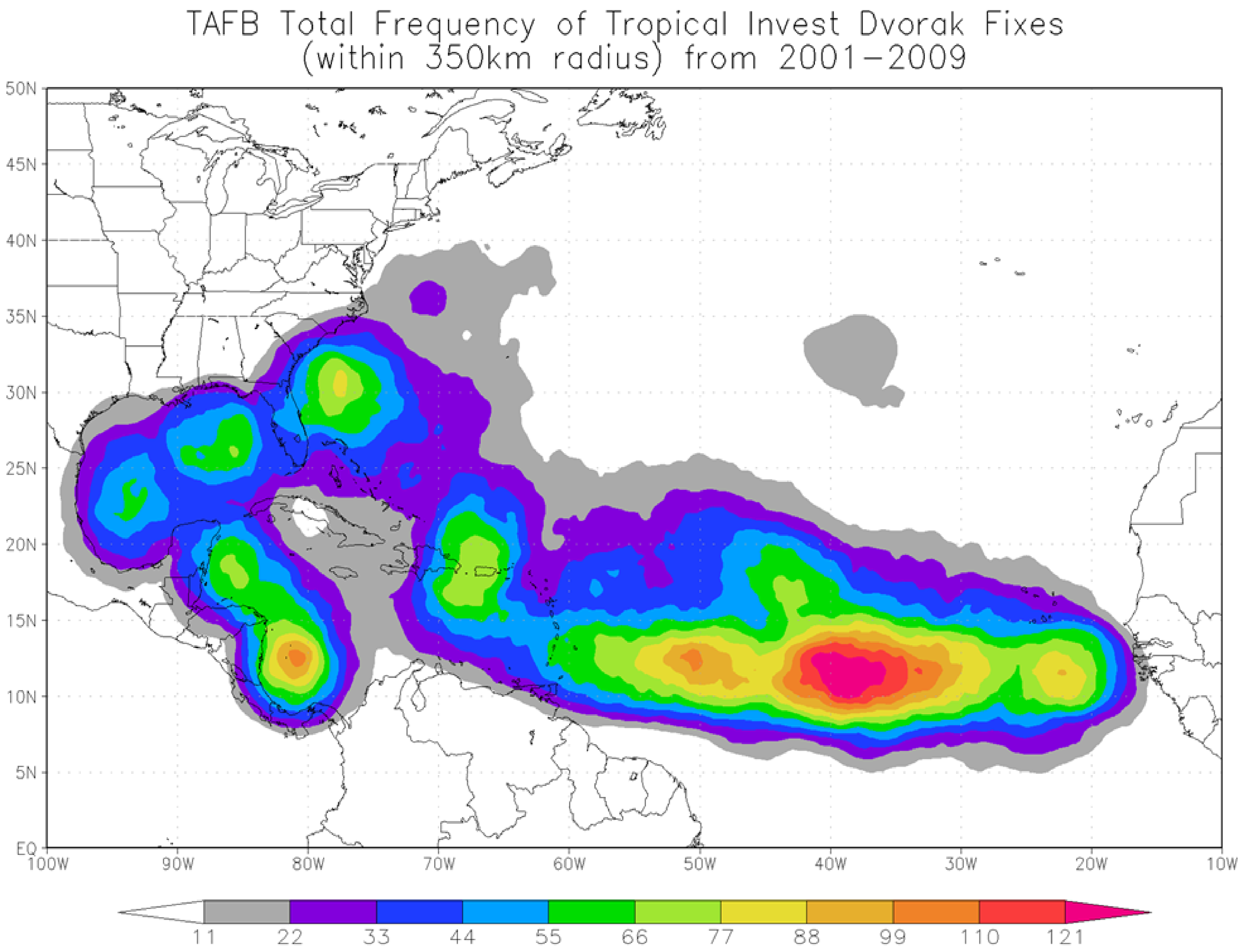




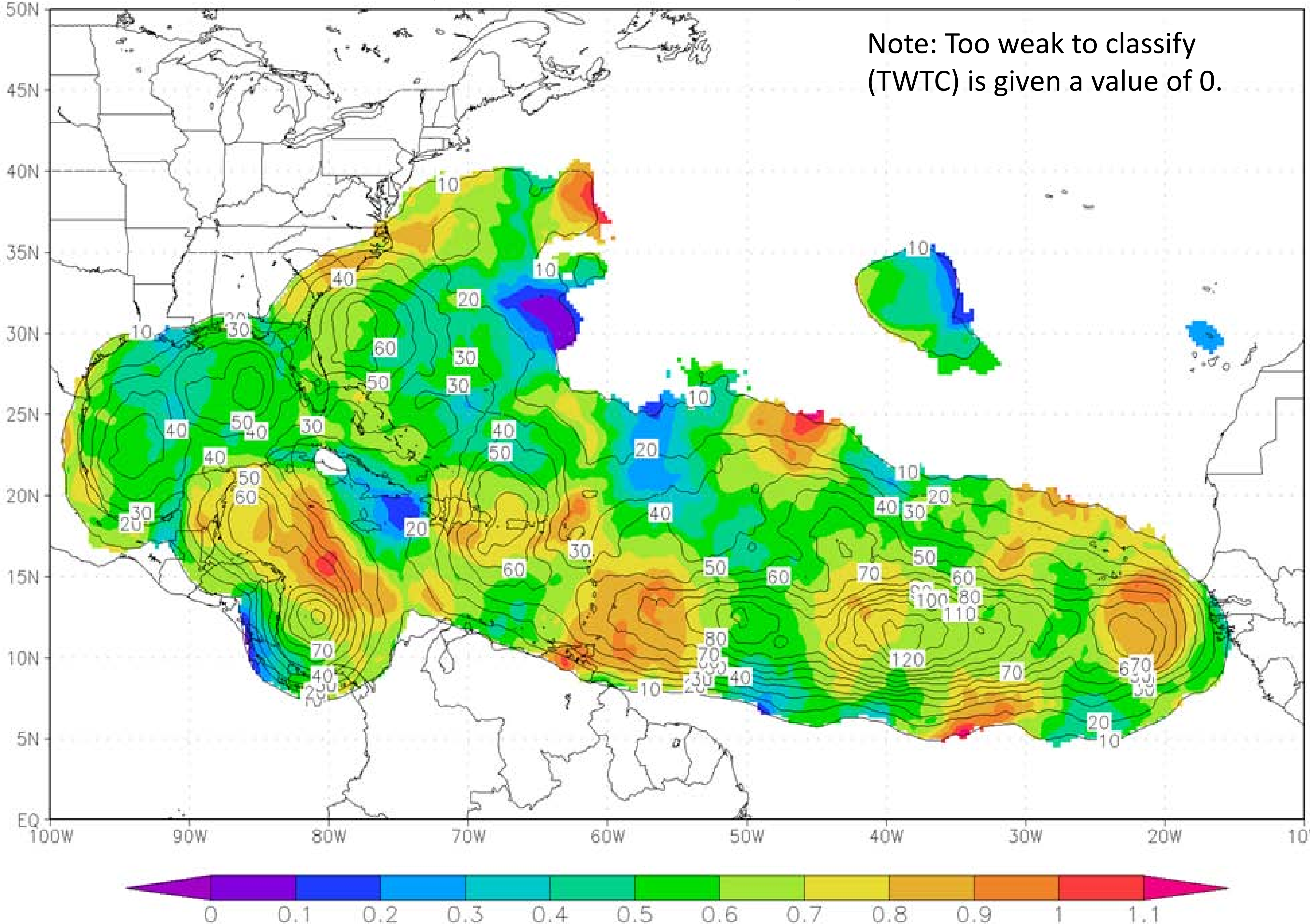
- The following analysis focuses on the regional variability of invest locations in the Atlantic basin through TAFB fixes.

ALL Atlantic TAFB Invest Dvorak Fixes (2001–2009)

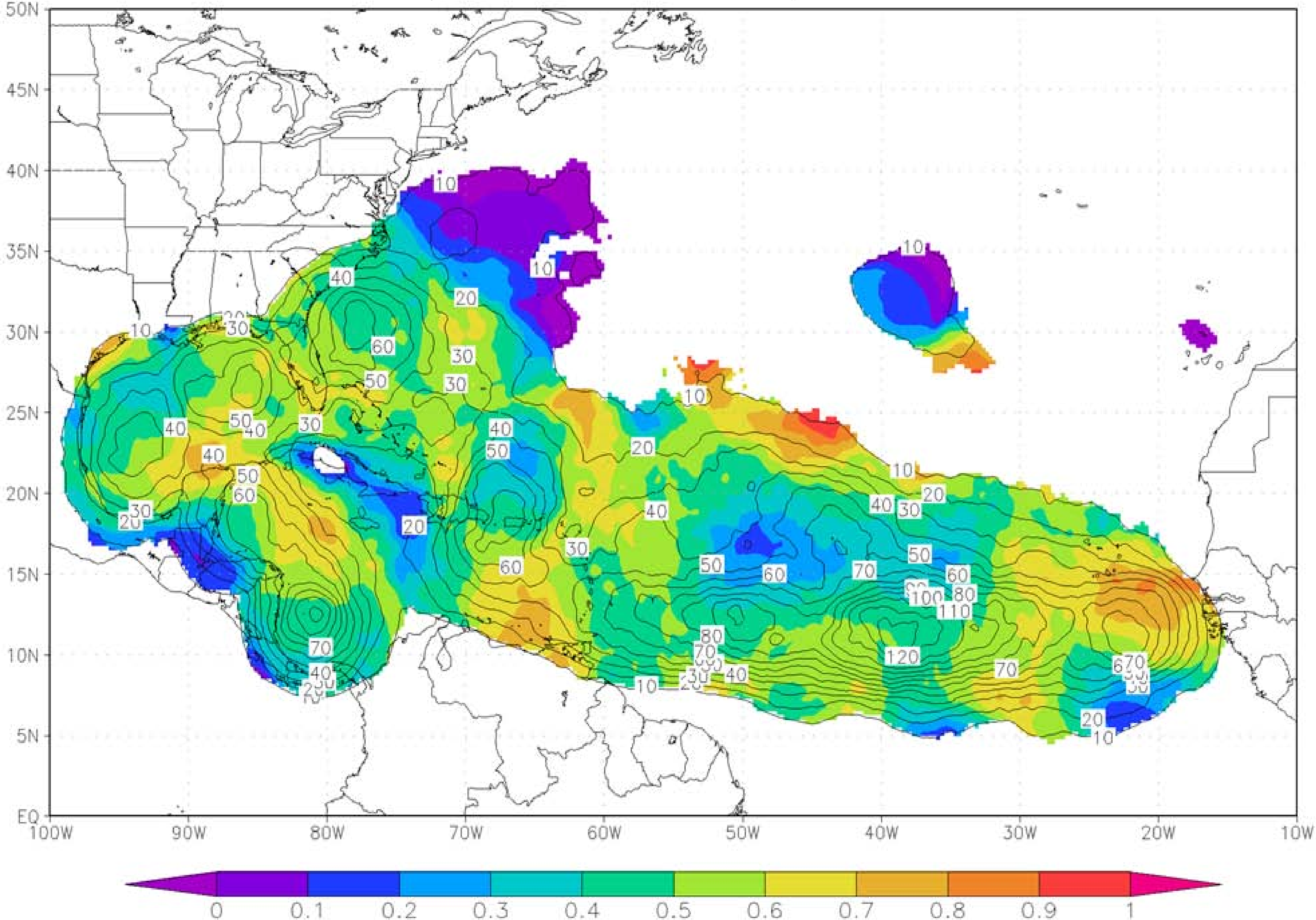



TAFB Total Frequency of Tropical Invest Dvorak Fixes
(within 350km radius) from 2001-2009
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
11
22
33
44
55
66
77
88
99
110
121

TAFB Mean Dvorak Fix (shaded) and Total Frequency (contoured) for Invests (within 350km radius) from 2001–2009

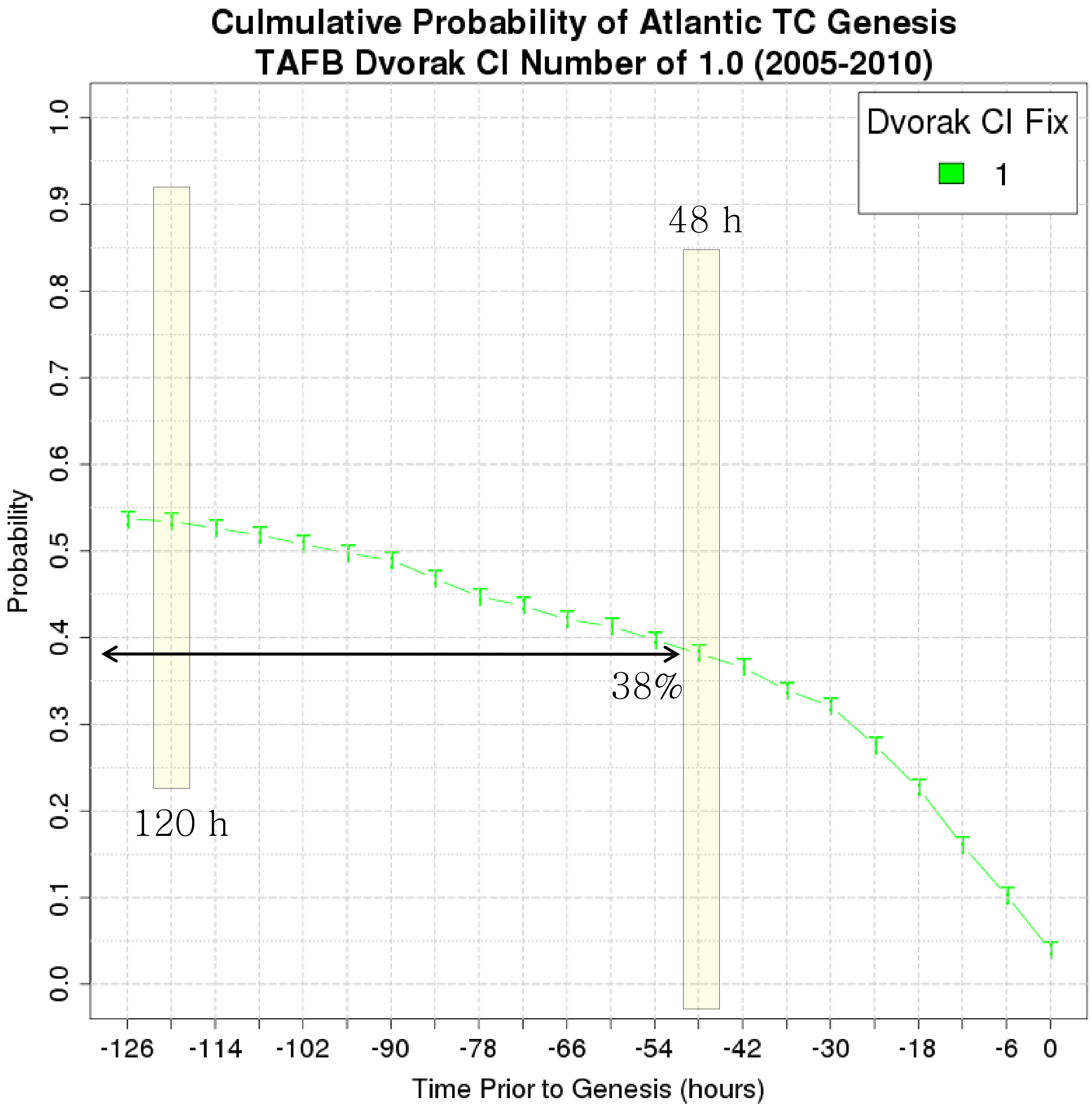


TAFB Genesis Rate (shaded) and Total Frequency (contoured)
for Invests (within 350km radius) from 2001–2009



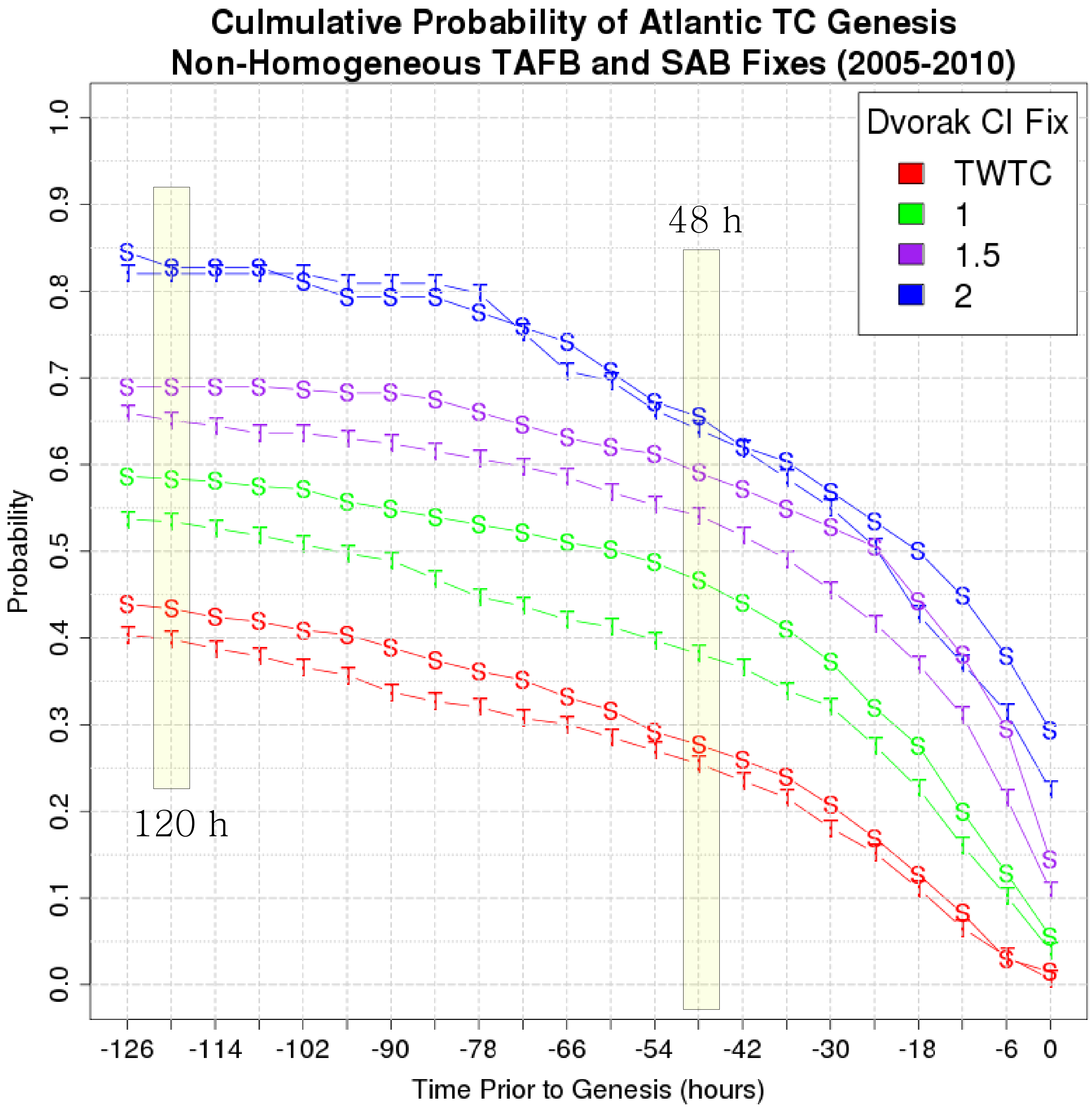
Spatial Variability of Disturbances

- Although there is a short climatological record, there appears to be preferred regions for tropical disturbances of interest.
- Areas of frequent Dvorak analysis of disturbances do not necessarily correspond to higher analyzed intensities or genesis rates.
  - Influenced by several possible factors
- The following probabilities results:
  - Group the Atlantic basin as a whole and does not look at the regional variability.
  - Compare TAFB and SAB analyses



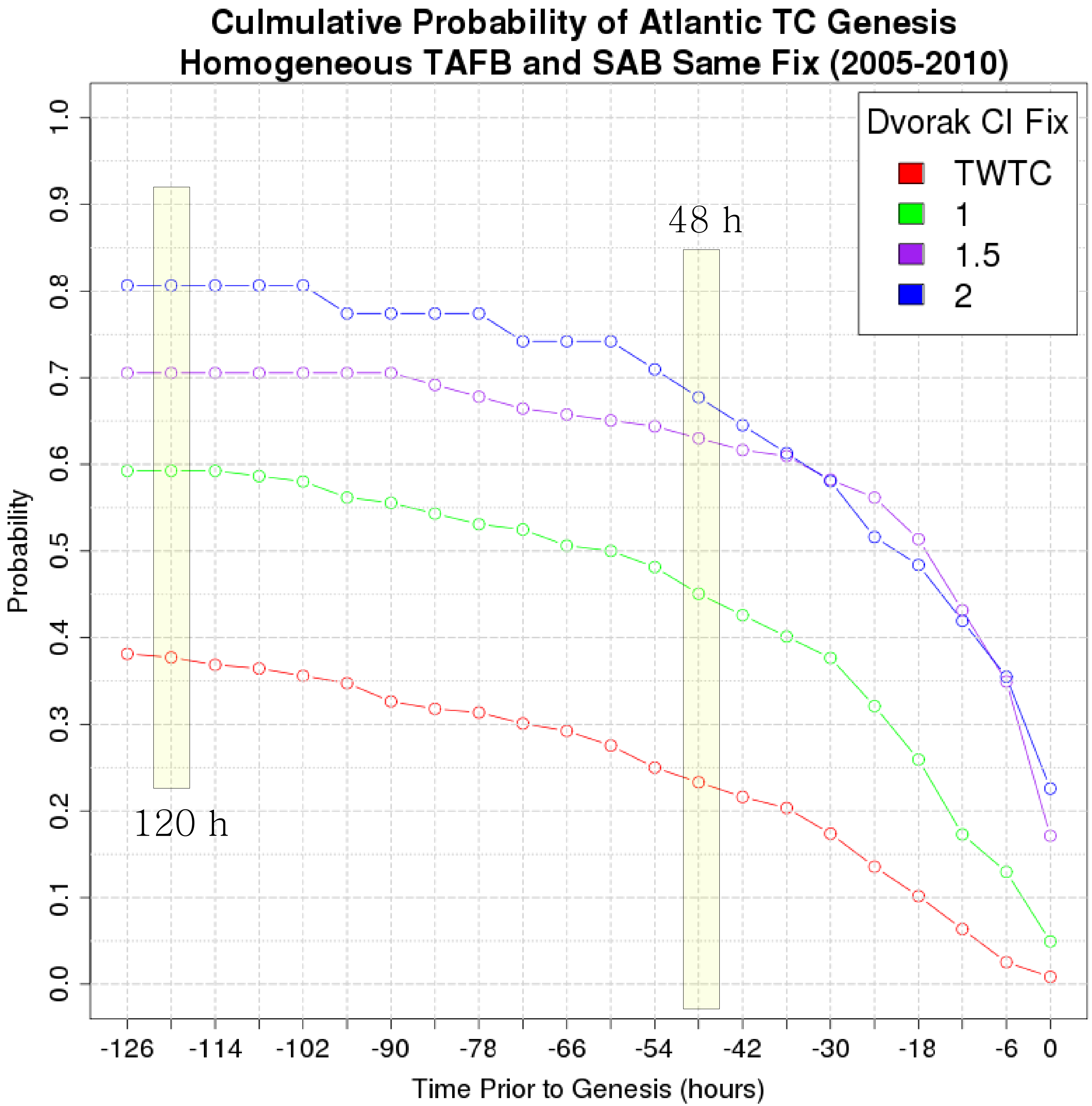
Example Graph:

- Each point shows the probability of genesis (on the ordinate) given a 6-hourly lead time (on the abscissa).
- In this case, the ‘T’ represents TAFB fixes while the green color corresponds to a CI number of 1.0.

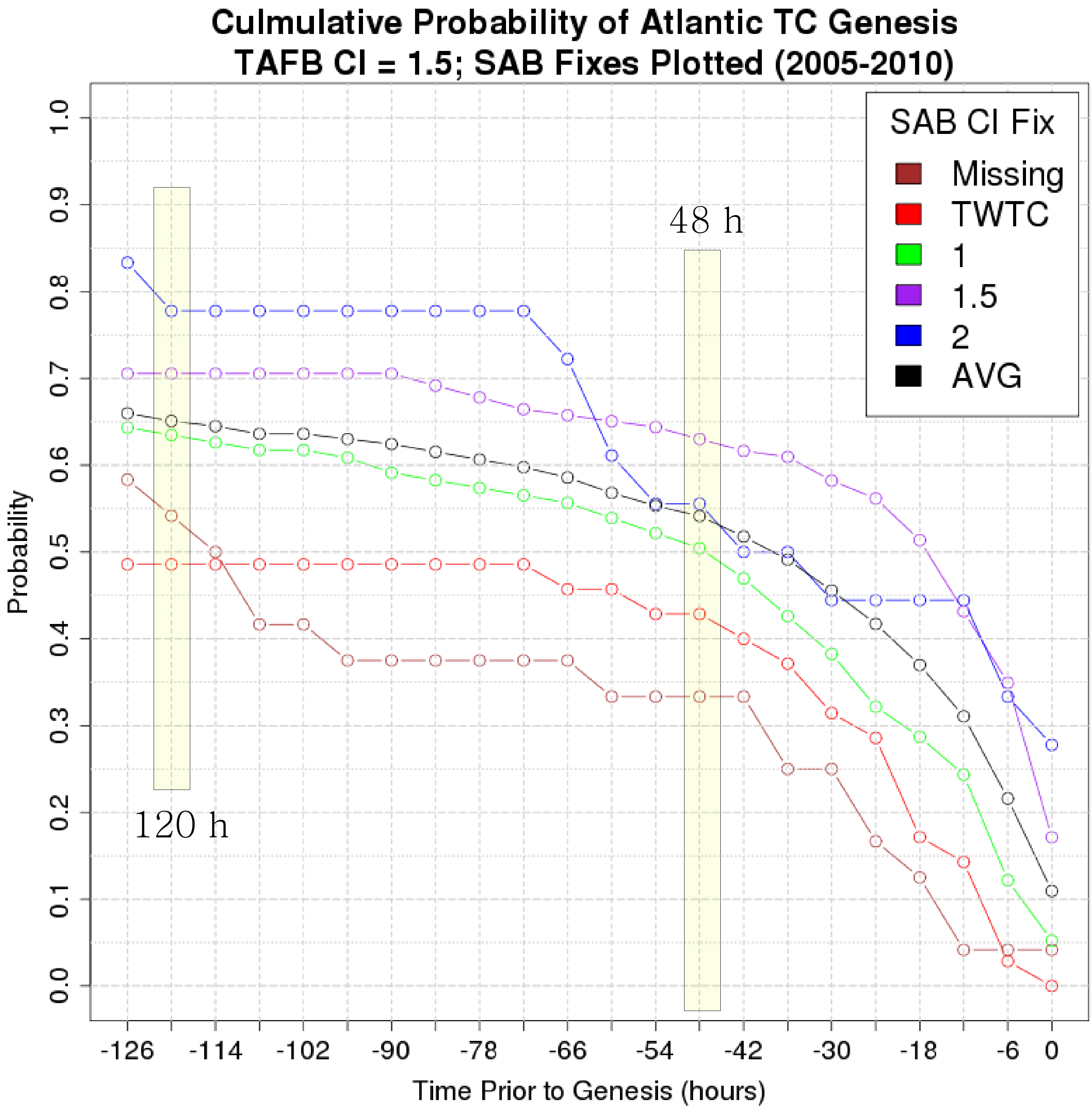


The probabilities of genesis from TAFB (T) and SAB (S) uses all available data from each respective agency.

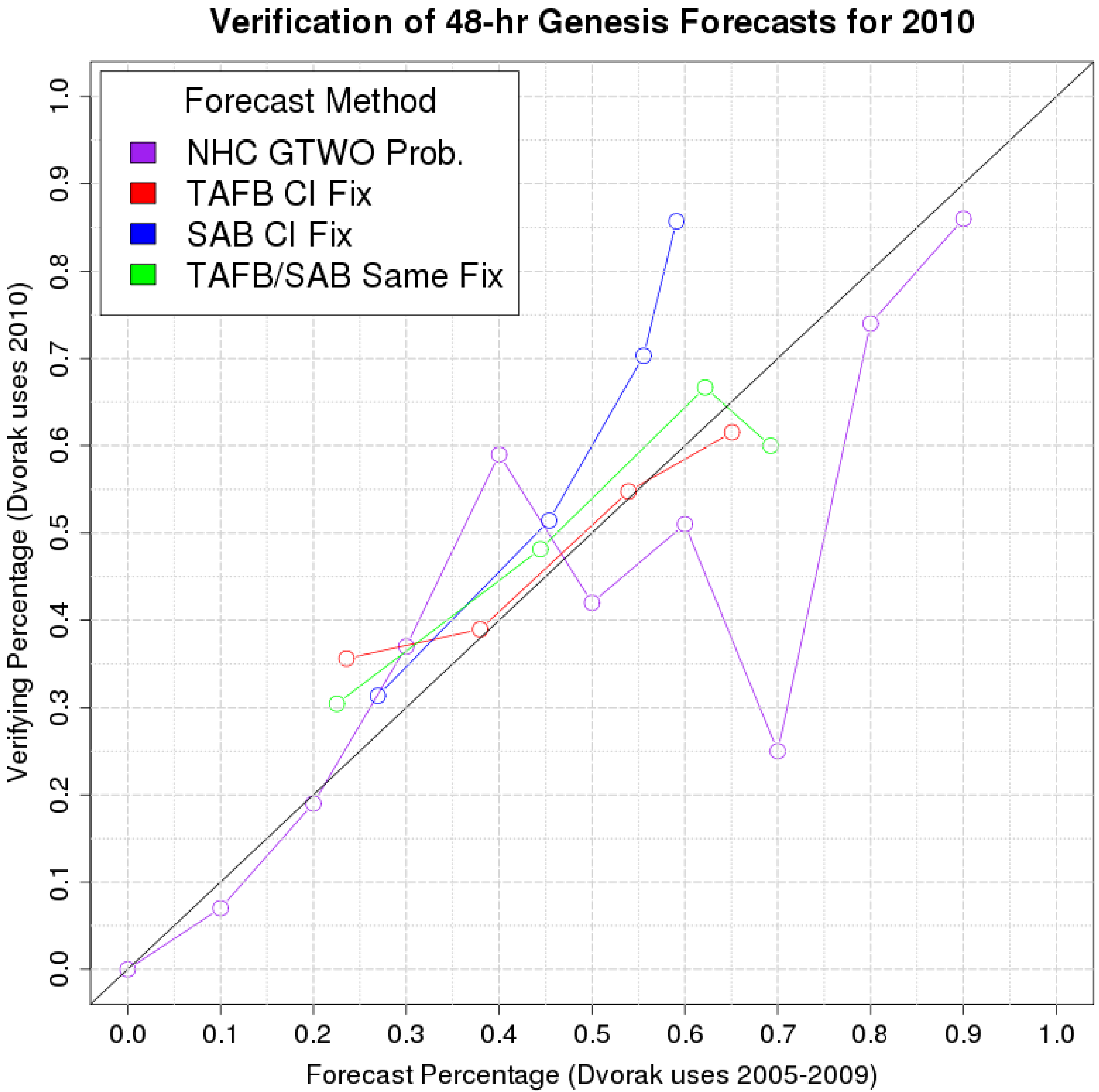
SAB probabilities are generally higher either due to missing data or fewer Dvorak fixes (especially on non-developing storms).



- This graph shows the probabilities of genesis when both TAFB and SAB share the same intensity estimate (e.g. both are TWTC for the same system at the same time).
- For 48 hr genesis probabilities, 1.0 and 1.5 CI numbers are 10% when SAB and TAFB agree, compared to using only TAFB.



- Since consensus approaches are often helpful, having Dvorak fixes from both agencies may add value to genesis forecasts.
- In this case, when TAFB analyzes a CI number of 1.5, SAB's analysis can help adjust the likelihood of genesis.
- For example, the probability of genesis for a system with a TAFB fix of 1.5 and a SAB fix of TWTC is higher than if SAB did not provide a fix (or it is missing).

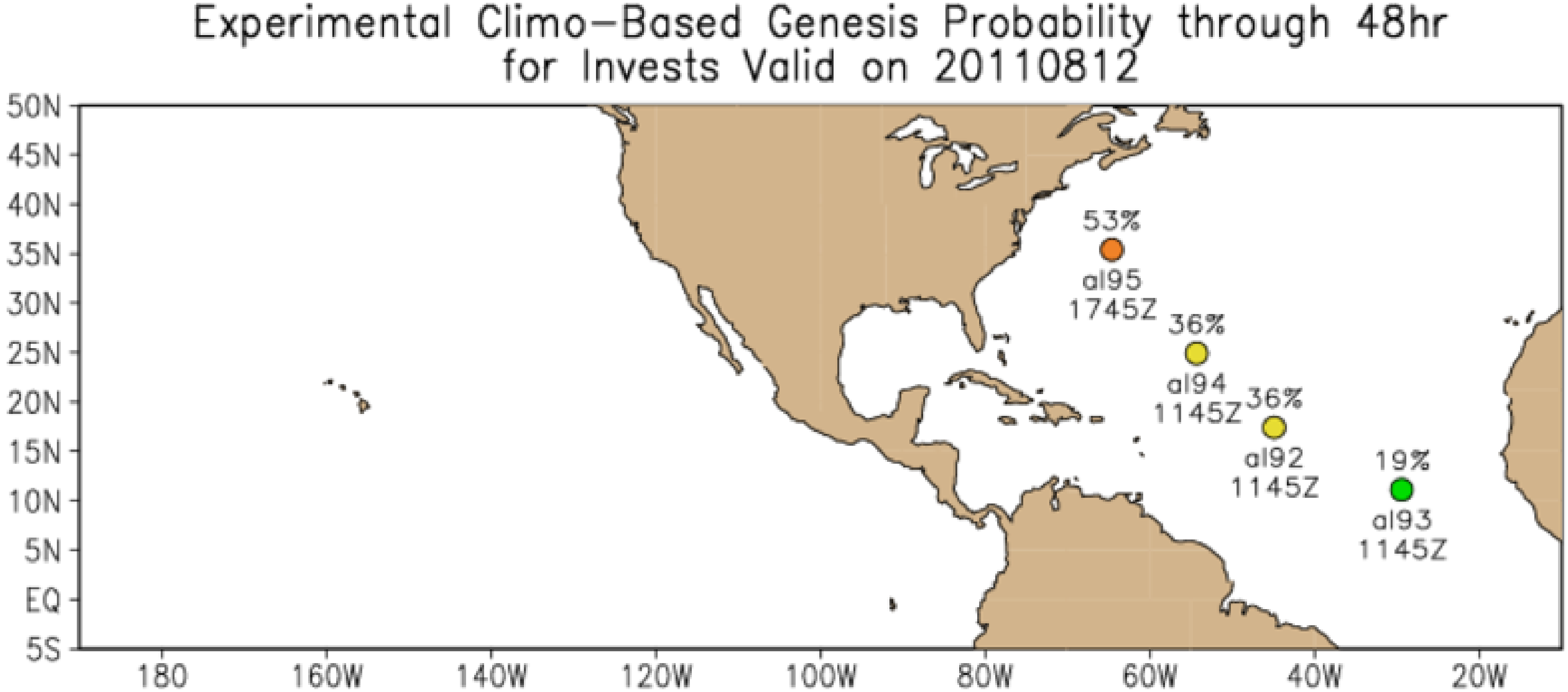


Dvorak forecasts (especially from TAFB) show comparable skill to NHC forecasts.

Probabilities using Dvorak analysis may be used to augment NHC performance in the more difficult middle percentage ranges.

Real-Time Guidance

Available at: ***http://moe.met.fsu.edu/genesis***



- Real-time probabilities are created and posted as the online ATCF system is updated with invest Dvorak classifications.
- Currently, basin-wide average probabilities are shown. Additional products and information will be made available as time permits.

Future Work on Genesis Probabilities

- Use additional predictors to refine the probability of genesis (e.g. time of year, location, history, etc.)
- Acquire data from JTWC and other RSMCs to expand probabilities to other basins.
- New JHT project ‘Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme.’
- Proposed collaboration with Chris Velden and his team to use this climatology to develop an ADT-like intensity estimation tool for disturbances.

Subjective versus Objective Techniques

- TC genesis is difficult to predict, not just for meteorological reasons:
  - When an invest crosses the disturbance/TC threshold is based on individual forecaster's determination.
  - Dvorak analyses are dependent upon a forecaster's subjective analysis.
- Diagnosis of the TC core verified by a broad range of remotely sensed and in-situ observations.
  - Objective methods can be developed to consistently identify structural patterns of TCs.

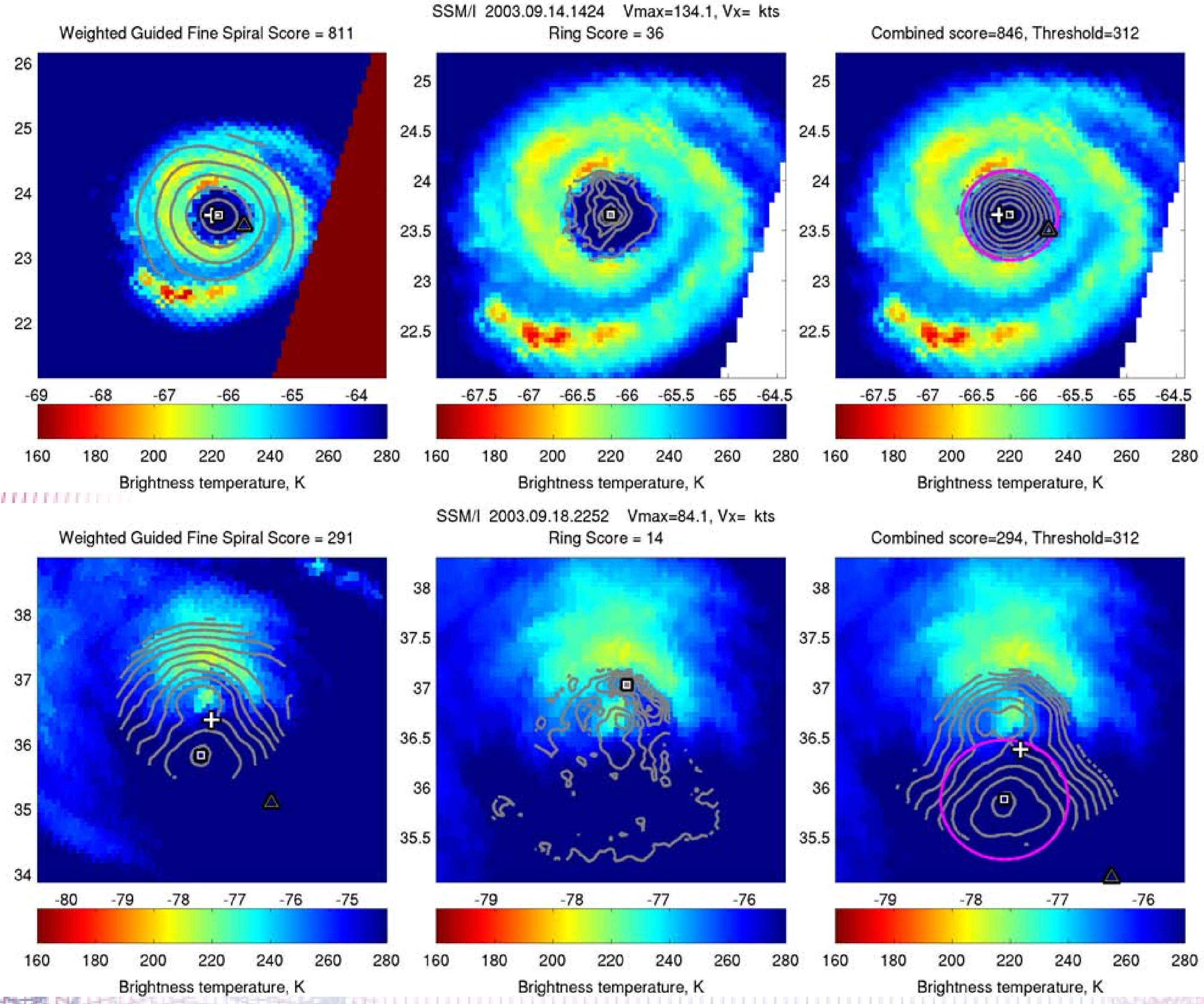
New Directions in TC Structure Diagnosis

- Despite numerous thrusts in numerical modeling (e.g. HFIP), statistical (e.g. DSHP) and consensus (e.g. ICON) models continue to have the highest predictive skill for TC intensity.
- However, these methods do not sufficiently incorporate the TC core and structure.
- Previous research (Piech 2007 and Murray 2009) have demonstrated that recon core observations by themselves skillfully predict short-term TC intensity.

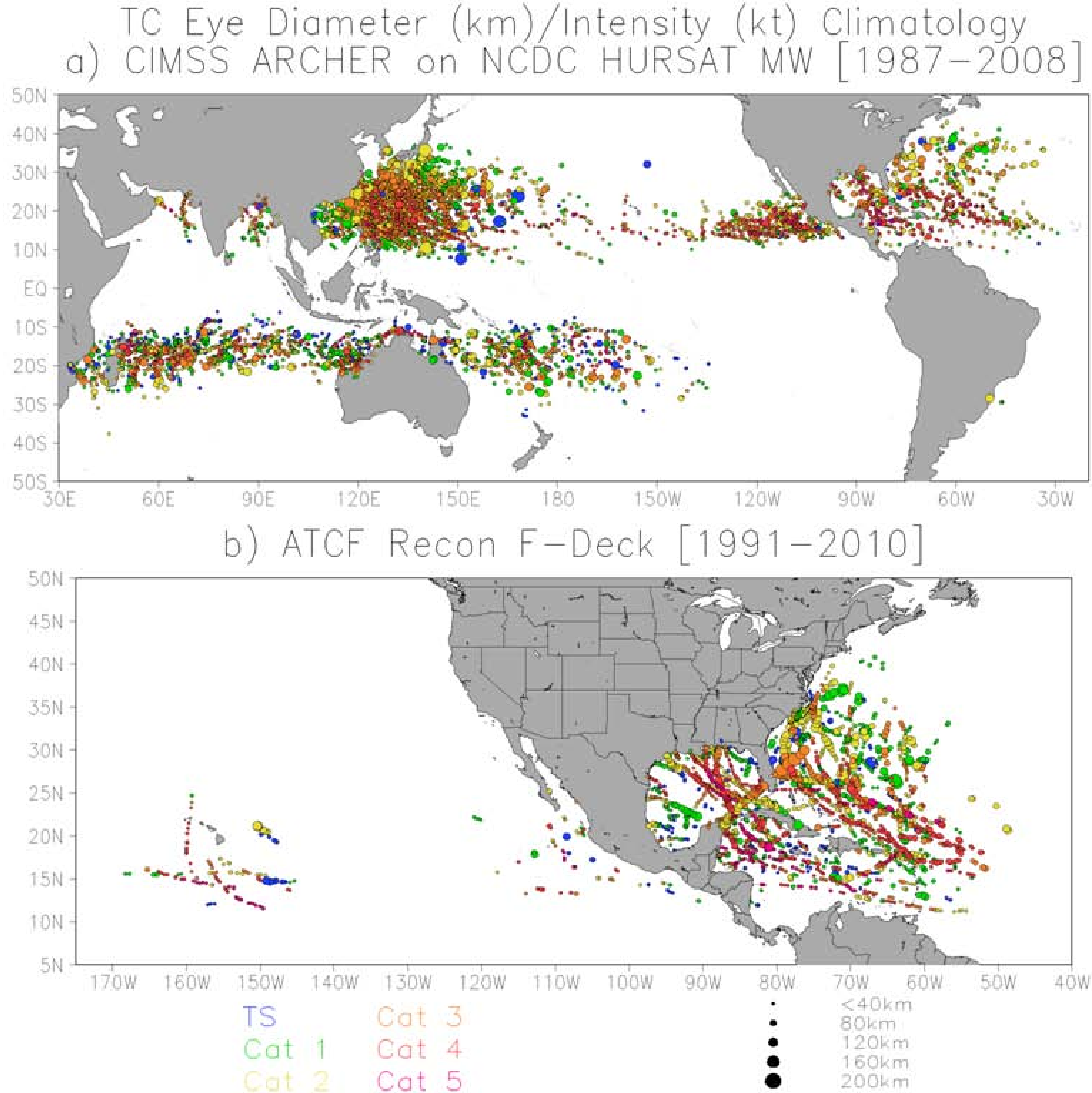
Methodology

- Data sources
  - Reconnaissance vortex data messages from the ATCF F-decks (1991-2010; AL, EP, CP)
  - HURSAT TC-centered SSM/I observations (1987-2009; worldwide)
- Recon data:
  - Reported eye diameter is compared to operational intensity analysis (ATCF A-decks)
- Satellite data:
  - TC center first guess by interpolated NHC/JTWC best track
  - ARCHER technique (Wimmers and Velden 2010) used to find satellite-based center and eye size
  - Eye size compared to interpolated best track intensity

ARCHER Technique



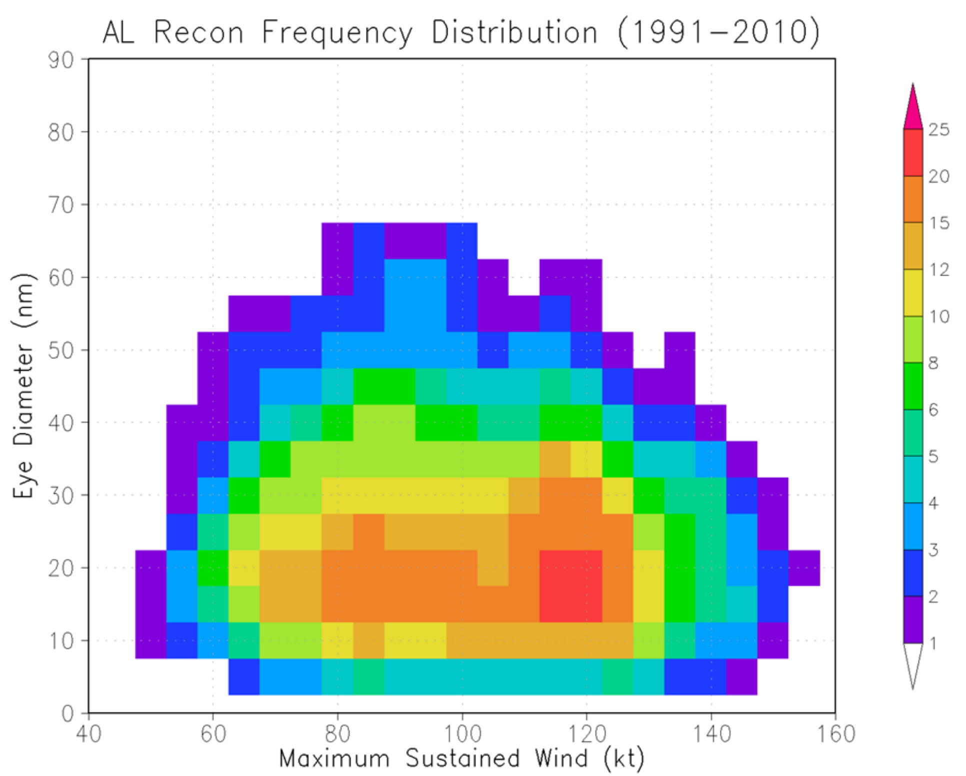
- Versions of ARCHER are used in ADT, MIMIC
- Uses information in satellite image to determine TC center.
  - Spiral banding (left)
  - Eye scene (middle)
  - Final center (right)
- Case used: Isabel 2003

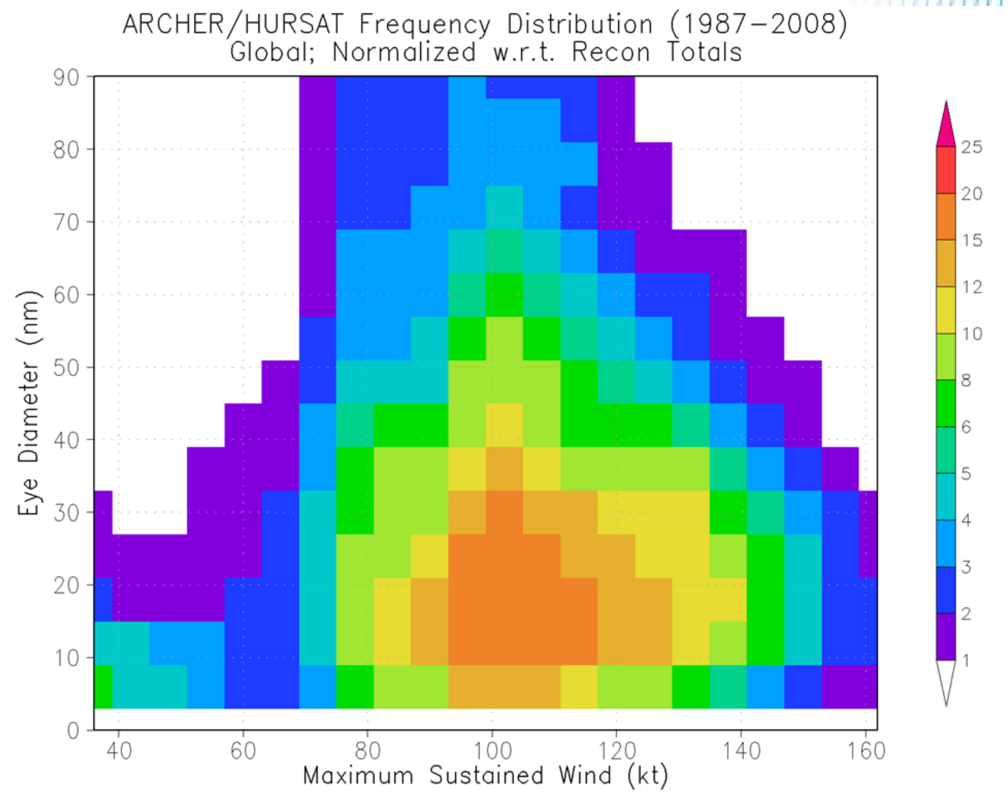


TC Eye Diameter (km)/Intensity (kt) Climatology
a) CIMSS ARCHER on NCDC HURSAT MW [1987–2008]
50N
40N
30N
20N
10N
EQ
10S
20S
30S
40S
50S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
b) ATCF Recon F-Deck [1991–2010]
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
170W
160W
150W
140W
130W
120W
110W
100W
90W
80W
70W
60W
50W
40W
TS
Cat 1
Cat 2
Cat 3
Cat 4
Cat 5
<40km
80km
120km
160km
200km

Frequency Distribution of Eye Size with Intensity

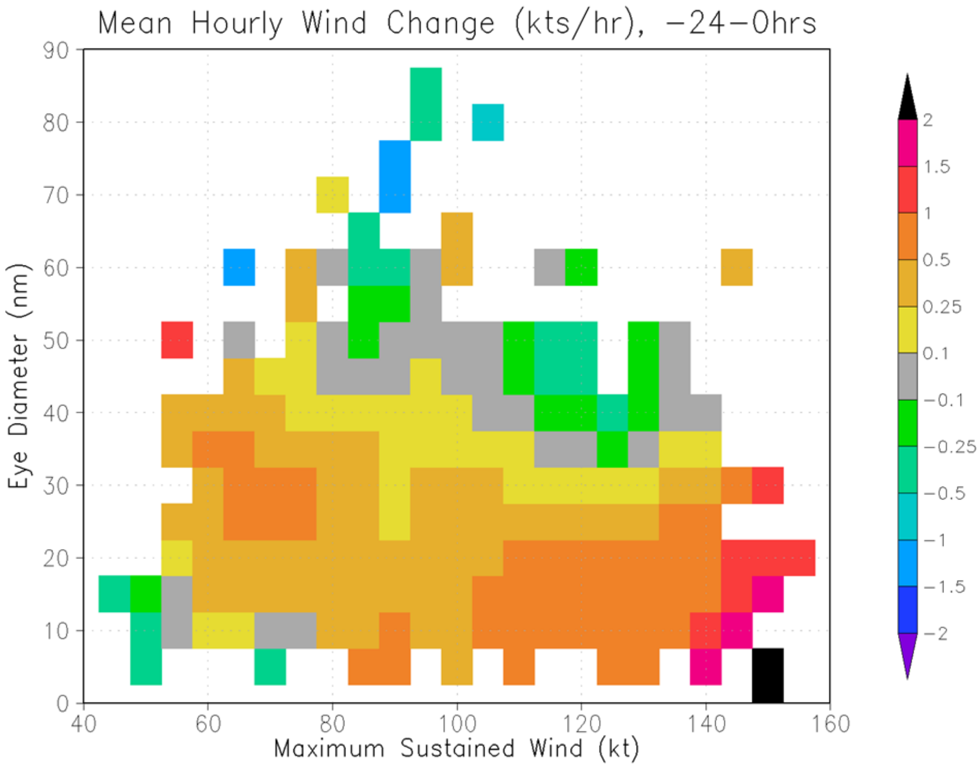
- There appears to be favored regimes of intensity with eye size, though there are caveats (e.g. imperfect filtering scheme with ARCHER/HURSAT; multiple similar observations in recon).
- Notes – 1.) Filtered once by a 9-point smoother. 2.) AL Recon in 5kt by 5nm bins; HURSAT is in 6kt by 6nm bins.

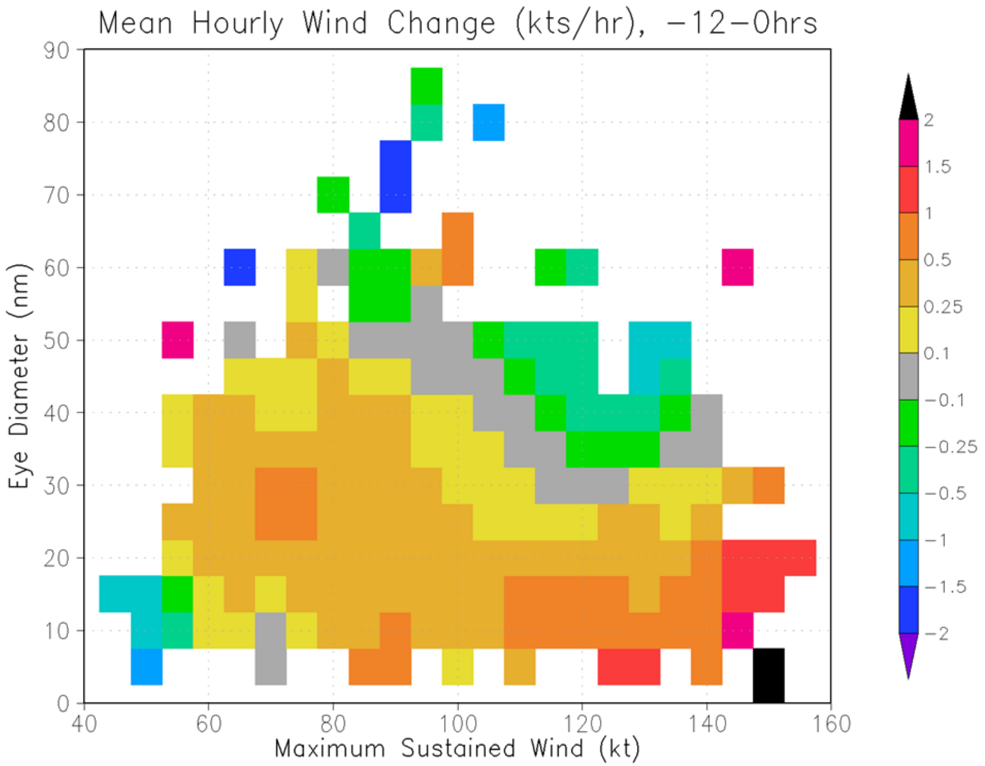




Climatological Intensity Change

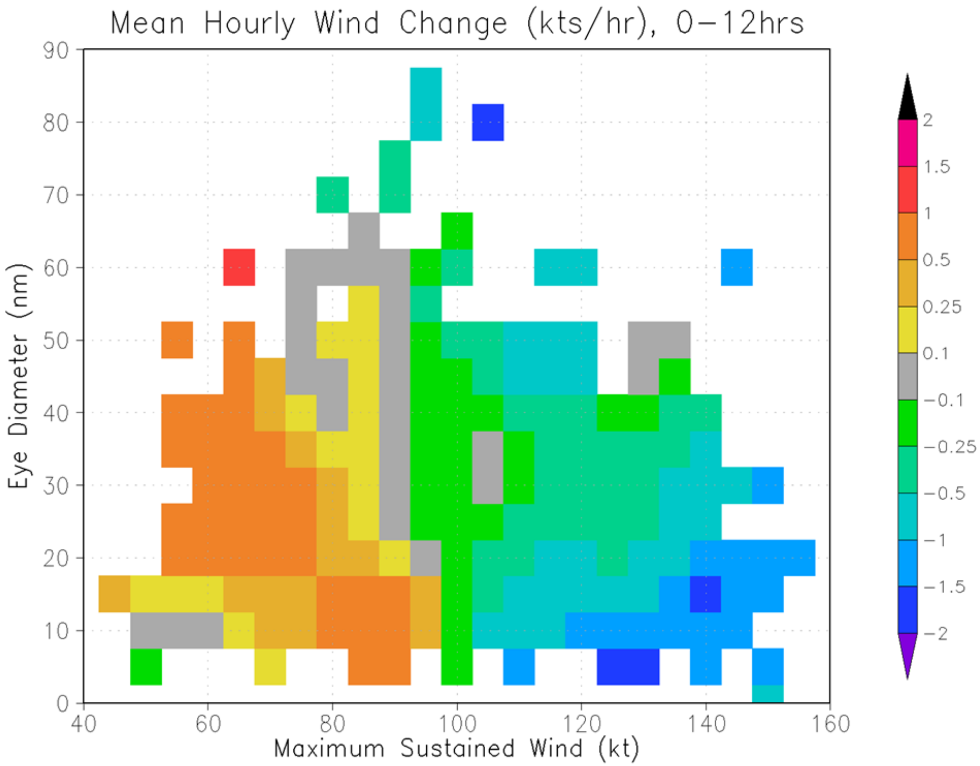
- Focusing on the Atlantic recon data, the rate of intensity change by current intensity and eye size can be examined. In the following figures, intensity change from the synoptic time preceding the recon fix ('0 hr') is examined.
- Below: hurricanes with medium to small eyes will, on average, quickly intensify in the hours *preceding* a recon fix.

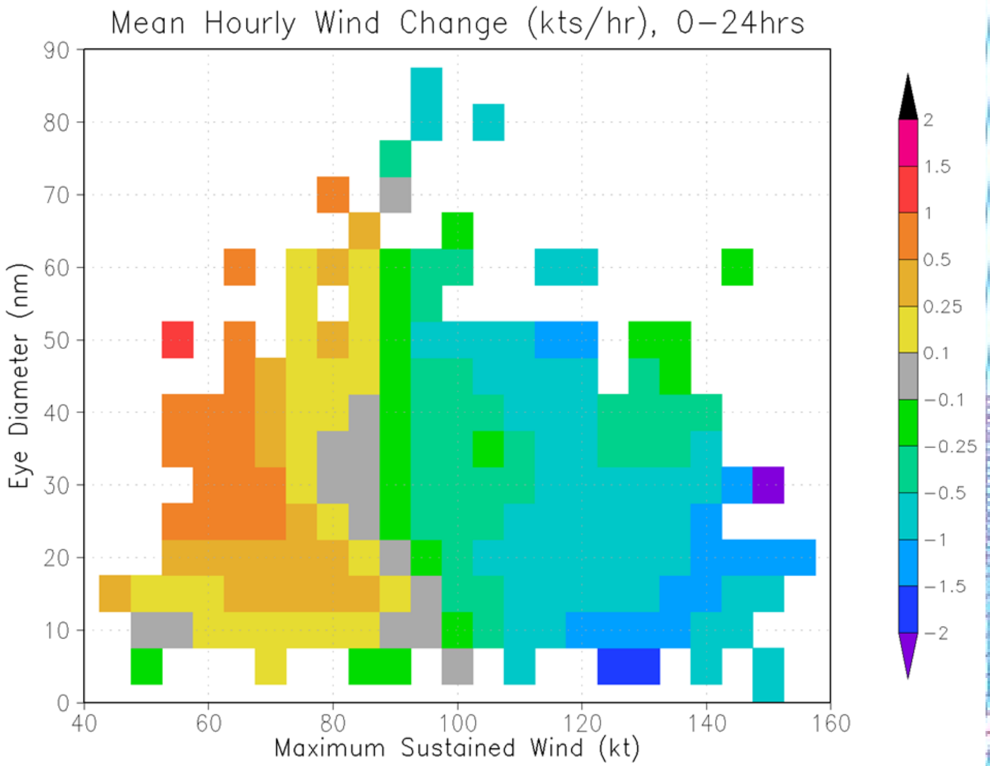




Climatological Intensity Change

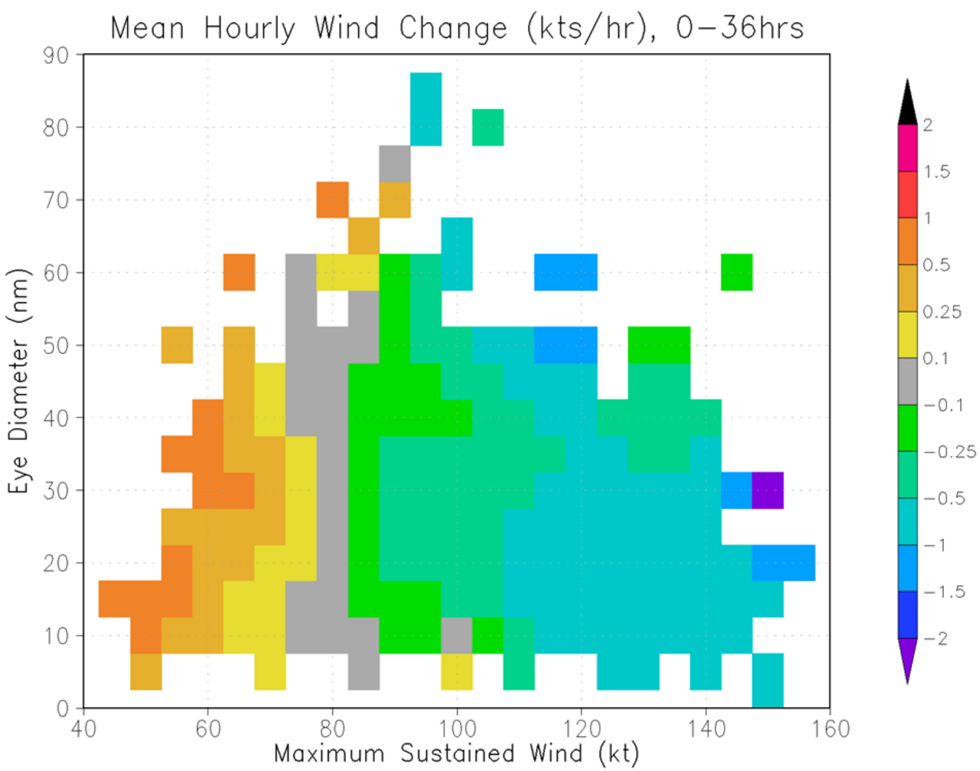
- After a recon fix, there appears to be a climatological intensity threshold above which a TC will weaken (or below which a TC will intensify). This threshold intensity goes down with lead time.
- Below, intensity change in the **12** and **24** hours *<u>following</u>* the recon fix is examined.

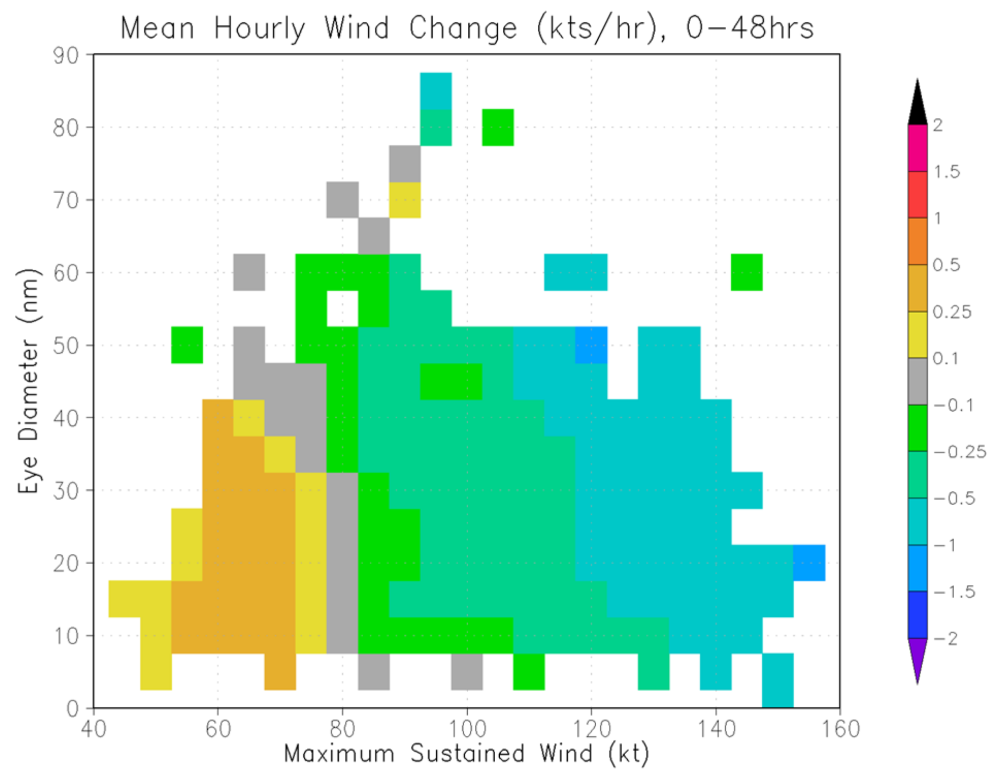




Climatological Intensity Change

- Well after a recon fix, there appears to be a climatological intensity threshold above which a TC will weaken (or below which a TC will intensify). This threshold intensity goes down with lead time.
- Below, intensity change in the **36** and **48** hours *following* the recon fix is examined.

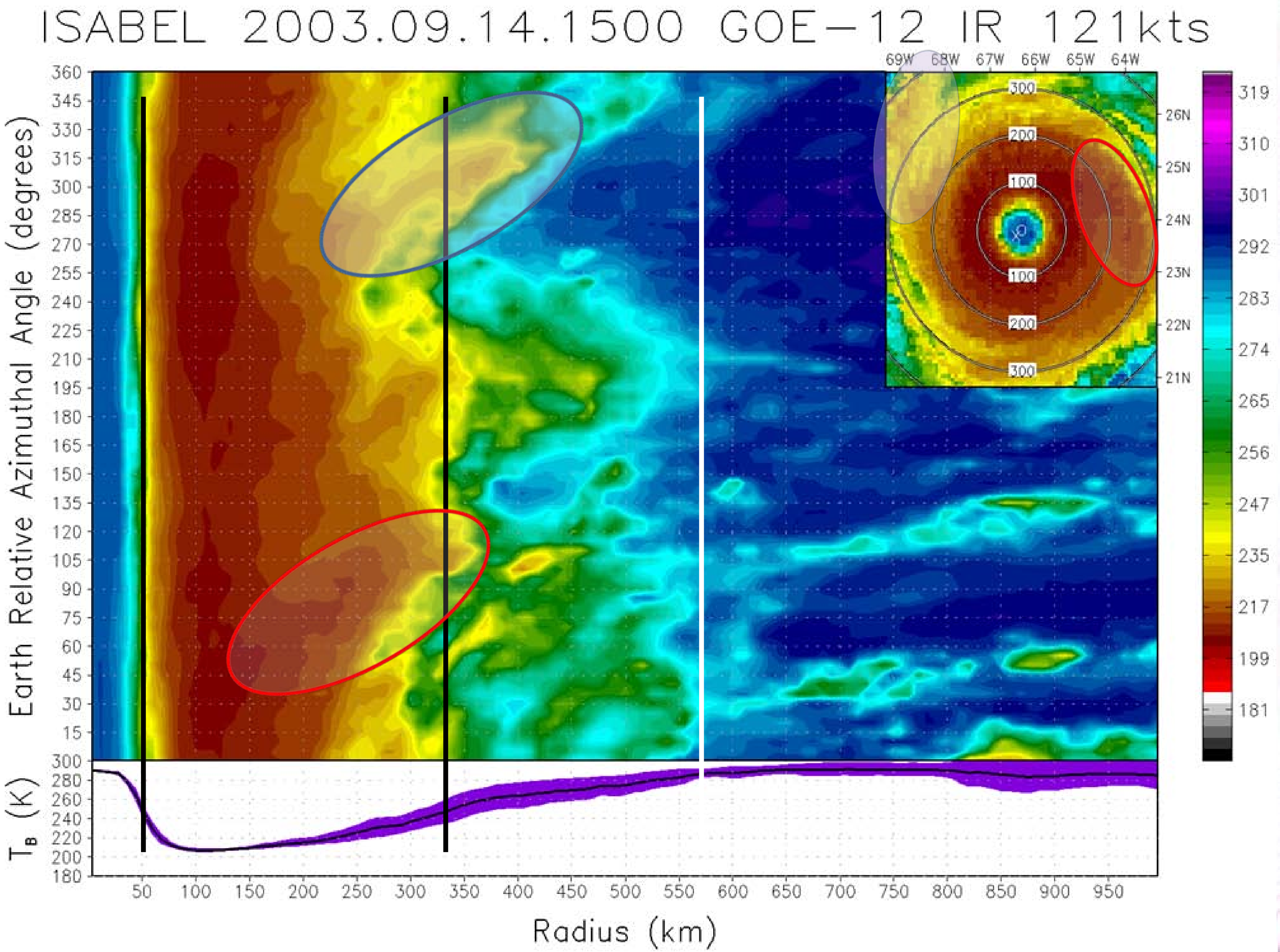




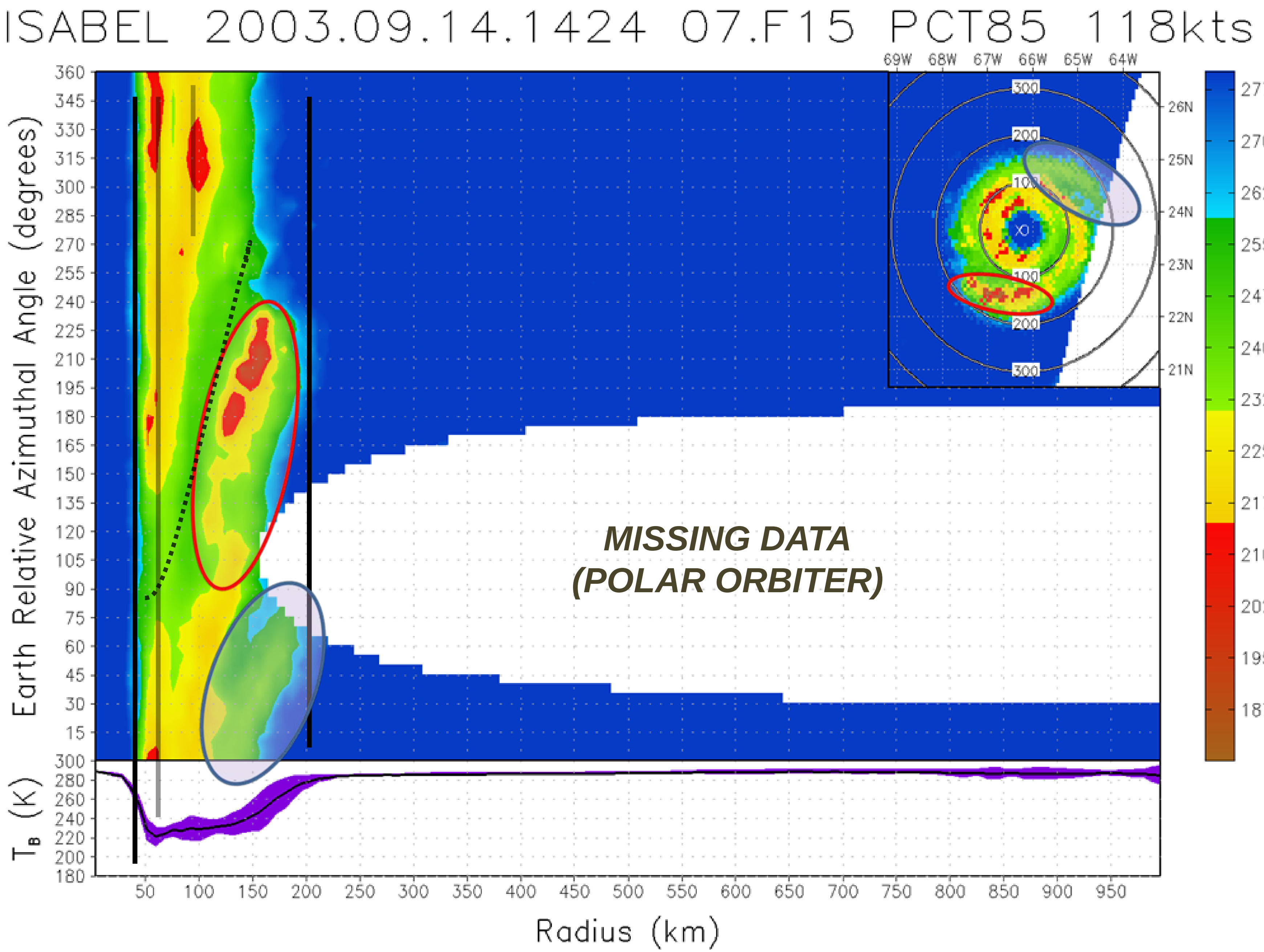
Eye Size as an Intensity Predictor

- There are preferred regimes of eye sizes and intensities, apparent in both recon data and HURSAT/ARCHER analyses.
- The current state of a TC's eye size and intensity can be compared to climatological changes in intensity for similar systems.
  - However, only looking at the eye size is too limited in scope to be able to determine the current and future intensity.
  - While such a tool is limited to recon fixes, satellite overpasses may be used as proxies of recon flights and can further examine storm to storm structure beyond the capabilities of recon flights.
- The greater areal coverage of satellite data allows additional observations of TC structure.

TC Natural Coordinate System

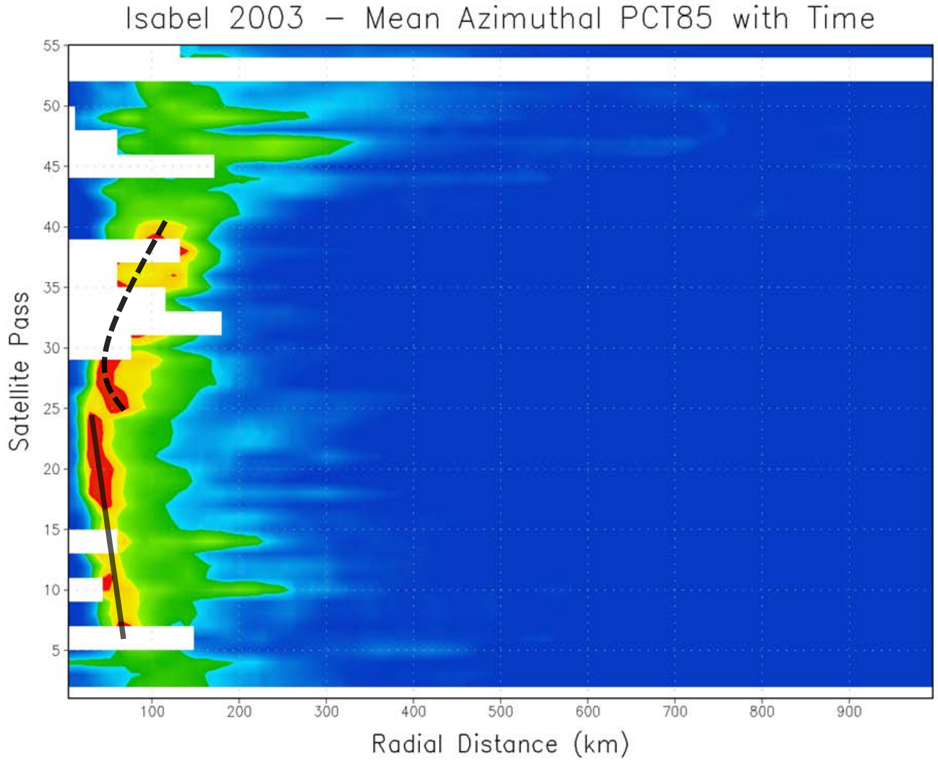


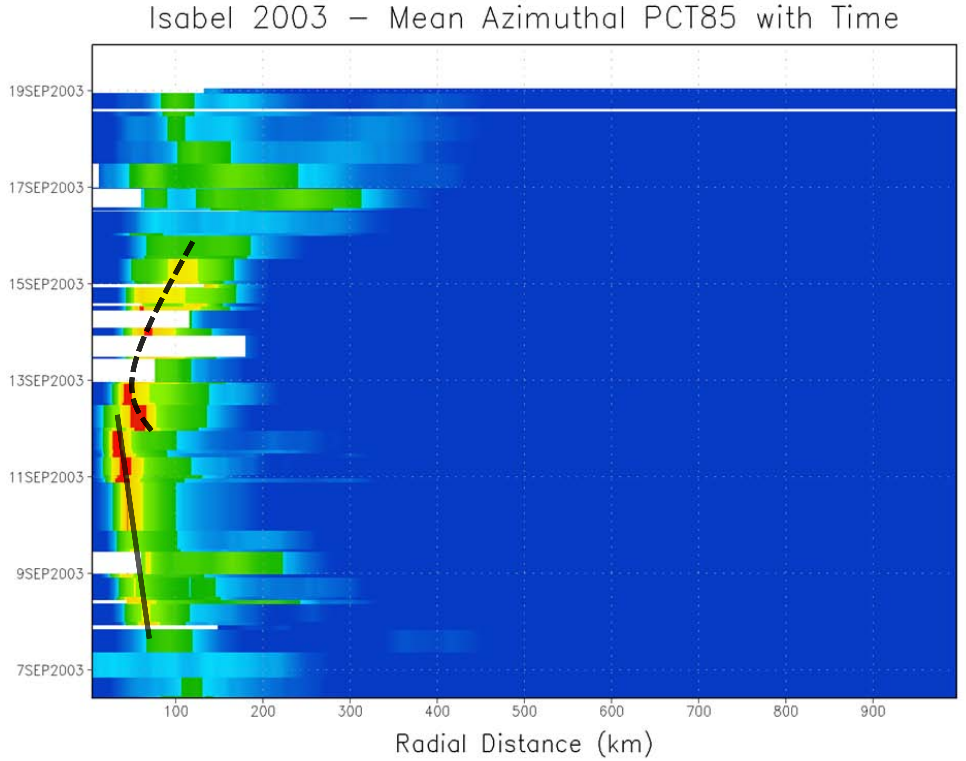
Identification of TC Structure



Evolution of Radial Structure

- Features of TC structure that can be better identified in radial or polar coordinates may be important factors in forecasts of intensity
- As with climatological intensity change from eye size, there may be analogs in the evolution of the TC core with time (below; by satellite pass on the left, by linear time on the right).





Identifying Precursors to Intensity Changes

- A polar coordinate system can help in interpreting structural signals in TCs
  - Size and symmetry of the eye and inner core
    - Signs of secondary eyewall formation
  - Banding structure
  - Influence of shear or dry air
- Having additional such metrics and showing their change with time can help quantify routes of intensity change.

Conclusions

- There is utility in identifying TC structure towards forecasting intensity
  - Regimes of eye size with intensity
  - Eye size and current intensity suggest climatological paths of future intensity
- Satellite observations (especially in the microwave frequencies) can be used to diagnose structure and intensity change
- We are continuing research into objective real-time tools to foster such goals.

Acknowledgments

- References

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