Development of a Probabilistic Tropical Cyclone Genesis Prediction Scheme

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Acknowledgements

Discussion Outline

- ## Motivation:
  - -explore utility of an <u>objective</u>, <u>disturbance-centric</u> scheme for identifying the probability of TC genesis

    **brainstorm credit: NHC's visiting scientist program & a quiet tropical NATL

- ## Current TC Genesis Efforts
  - -NESDIS TC Formation Probability (TCFP) Product
  - -NHC's Genesis Tropical Weather Outlook

- ## Tropical Cyclone Genesis Index (TCGI*)
  - -Year 1 efforts (completed & ongoing)
 - -Year 2 efforts (proposed)

- ## Conclusions & Future Work

*1st Runner-up: Genesis Index GI (GI)

*2nd Runner-up: **G**enesis **o**f **N**ascent **F**orming **S**torms and **H**urrica**n**es (GoNFSHn)

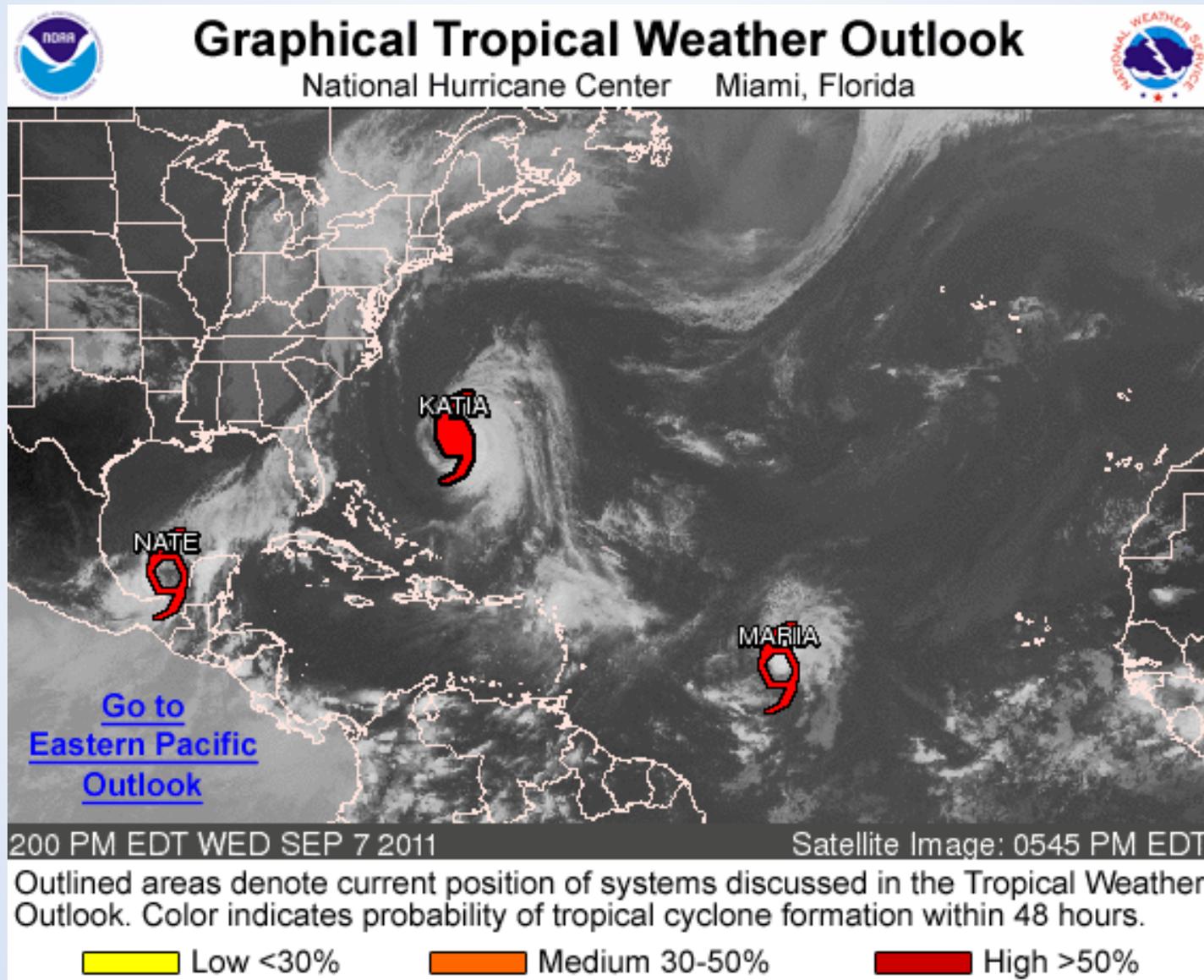# NESDIS Tropical Cyclone Formation Probability (TCFP) Product

- Statistical algorithm estimates probability of TC formation in 5 x 5 grid boxes in the next 24 hours

- Uses **environmental** (GFS analyses), **convective** (geostationary water vapor) and **TC-related** (b-decks) predictors

- 3-step algorithm
    1. Screening
    2. Linear discriminant analysis
    3. Relates LDA value to past occurrence frequency

- Covers global tropics (45 S to 45 N)
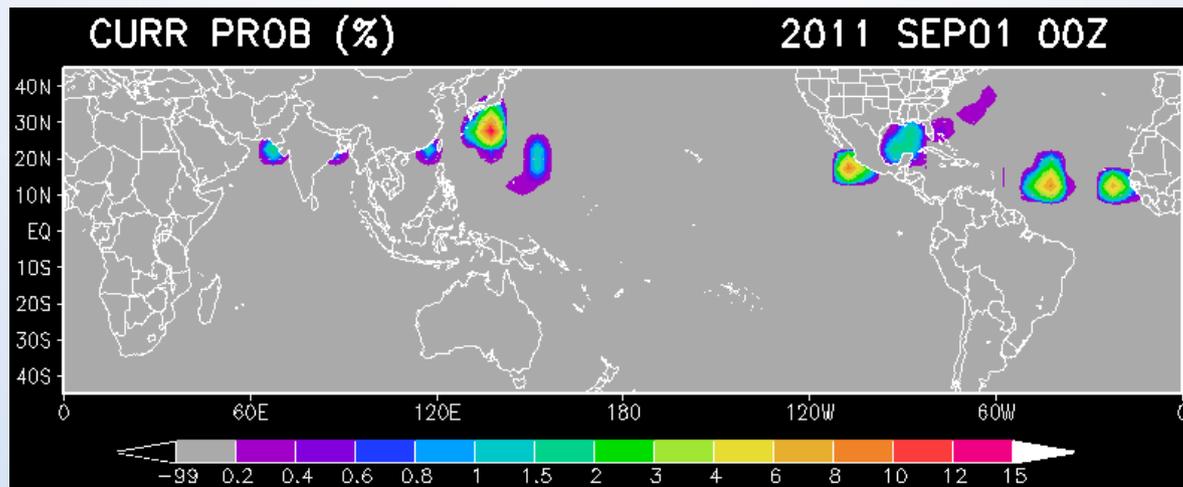
NESDIS TCFP (cont…)

- TCFP is skillful with respect to climatology

- However, maximum probabilities are relatively low (10-15%)
    - large when compared to climatological probabilities (<1%)
    - …but still too small for forecaster confidence
    - due in part to large ratio of "no" forecasts to "yes" forecasts (on order of 650:1 after screening step)
    - consequence of computing over a fixed global domain

NHC's Tropical Weather Outlooks

Graphical Tropical Weather Outlook
National Hurricane Center   Miami, Florida

KATIA

NATE

MARIA

Go to
Eastern Pacific
Outlook

200 PM EDT WED SEP 7 2011   Satellite Image: 0545 PM EDT

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

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

# NHC's Tropical Weather Outlooks

- **Product Highlights**

   -conducted routinely at NHC since 2007;

   -highlight areas of disturbed weather & potential for TC development during the following 48-hr;

   -describes the probability of genesis (0 to 100%, in 10% increments) for each area of identified disturbed weather;

   -"middle ground" probabilities (~40-70%): most challenging

   -probabilities represent the forecaster's subjective determination of the chance of TC formation;

   -subjective process: limited objective tools for providing additional guidance;

Tropical Cylone Genesis Index (TCGI)
Utilize advantages of TCFP & NHC TWOs
Probability of Genesis: 0-48 hr & 0-120 hr

TCFP
objective
earth-centric
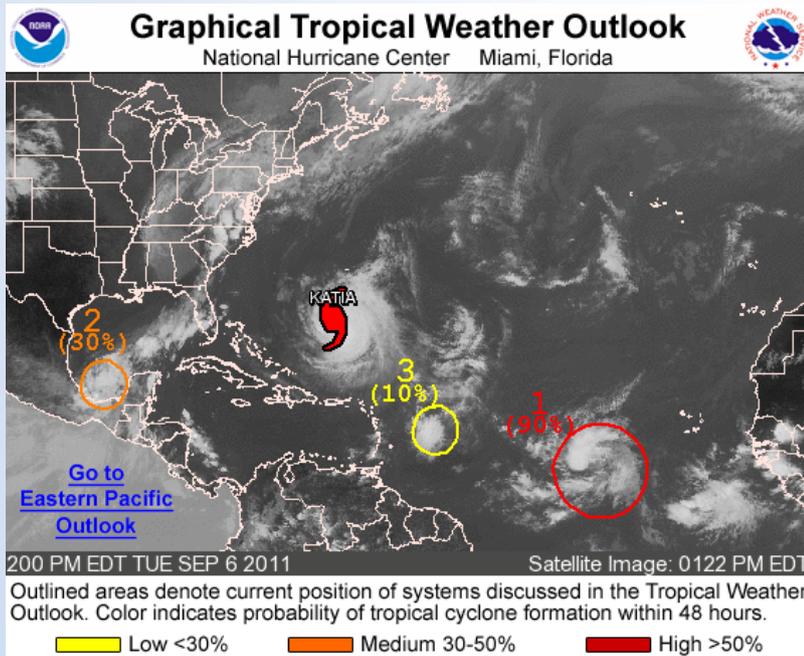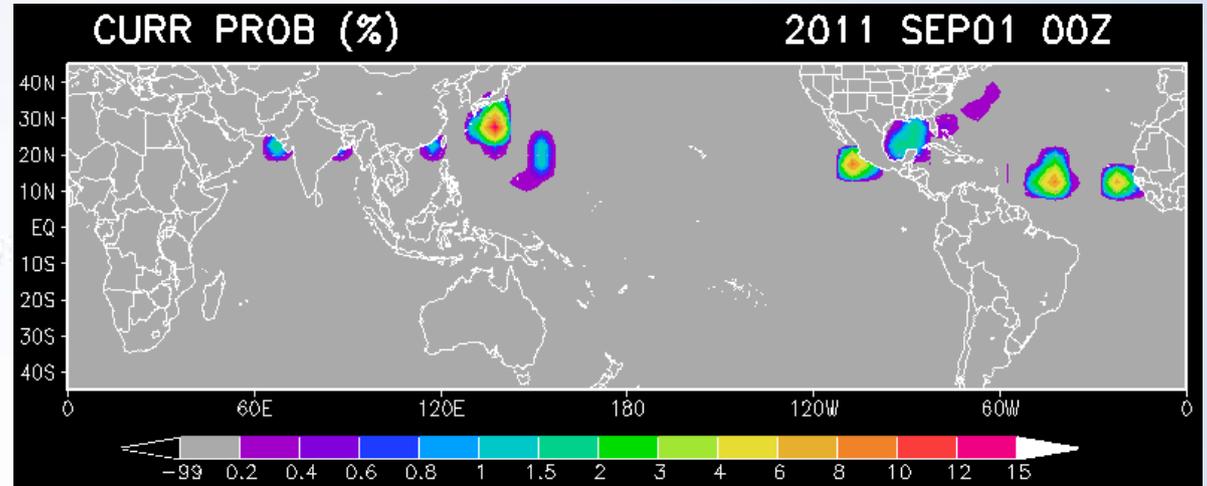
NHC TWOs
subjective
disturbance-centric

Timeline: Year-1
(near completion)

- ## Feb 2012:
  -Complete identification/development of TCFP environmental predictors into the TCGI database

  -"the devil's in the details"
    1) requires a comprehensive (10-yr) "Invest Best track"
        -Dvorak database (Cossuth);

    2) need to build a complete, continuous "Invest Best track" from the Dvorak dataset;

- ## Feb 2012:
  -Begin to develop/incorporate the TPW predictor into the TCGI database

- ## March 2012:
  -Present year-1 results at IHC

Timeline: Year-1
(upcoming)

- **June 2012**:
  -Complete identification/development of TPW & Dvorak T-number/CI value TCGI predictors

- **June-Nov 2012**:
  -Begin sensitivity testing for optimal combination of TCGI predictors (0-48h & 0-120h)

  -utilize RI Index methodologies (Kaplan)
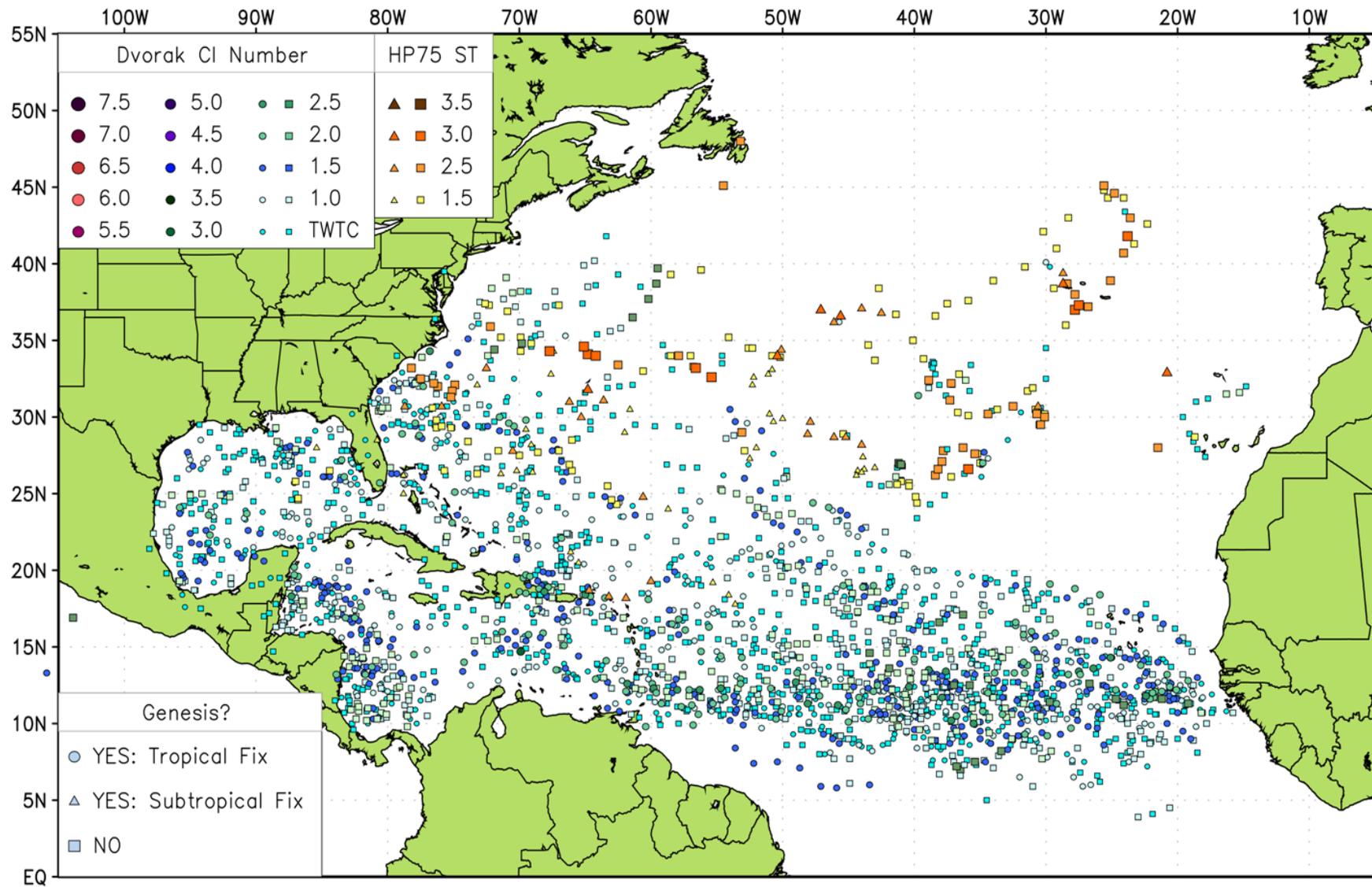
Dvorak Dataset

- **Data**
  - -developed by Josh Cossuth/Rick Knabb
  - -North Atlantic (2001-2010)
  - -T-Num & CI values from NOAA TAFB
  - -pre-genesis disturbances (usually TWTC through 2.0)
  - -includes developers & non-developers
  - -TWTC systems: assigned 0.5 T-num/CI value

- **Track Information**
  - -provides much of the the "backbone" of the TCGI track database development
  - -tracks often discontinuous over space & time though
  - -determining invest positions (0-120 hr for each track point):
    - 1) Dvorak positions
    - 2) Interpolations
    - 3) Specially-developed BAMM model

TAFB Dvorak Fixes: Pre-Genesis Locations

TAFB Atlantic Dvorak Fixes: Genesis Dataset [2001–2010]

Dvorak CI Number Versus Genesis Probability

Culmulative Probability of Atlantic TC Genesis (TAFB; 2005-2010)
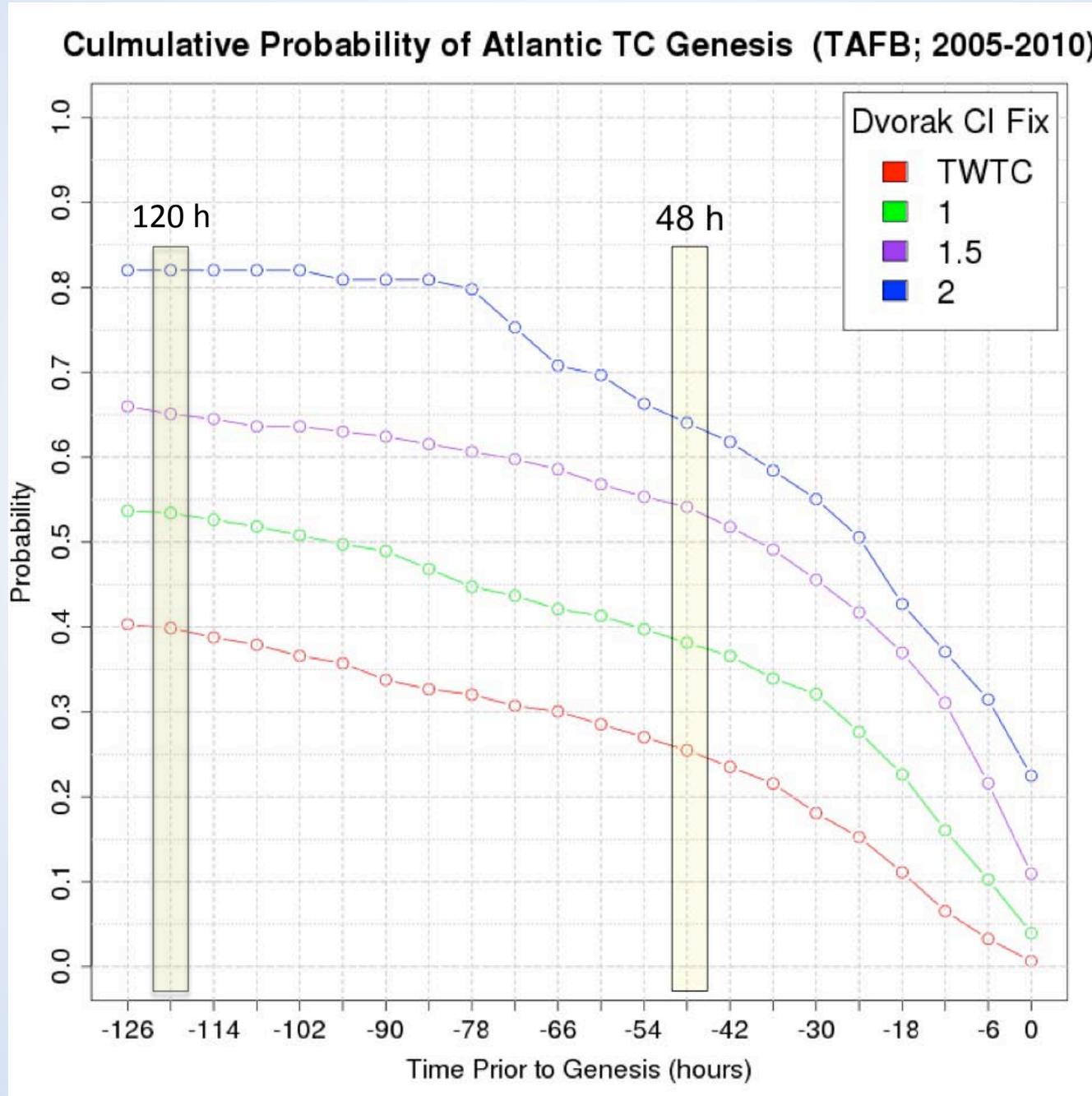
Developing TCFP predictors for use in TCGI

- Identified TCFP predictors that can be used in disturbance-centric framework

- Using Dvorak dataset to identify developing & non-developing disturbance positions
    - Filling in missing forecast positions ("Invest Best Track")

- Using SHIPS-like algorithm to calculate disturbance-centric predictor values for sample

- Also testing:
    - SHIPS predictors
    - TPW
    - Dvorak T-numbers/CI Values

Potential Predictor	Data
850-200 mb vertical shear	GFS analyses
850-mb vorticity	GFS analyses
MSLP	GFS analyses
Vertical instability parameter	GFS analyses
850-mb horizontal divergence	GFS analyses
Sea surface temperature	Reynold's weekly SST
Latitude	Dvorak dataset
Distance to land	Dvorak dataset
% pixels colder than -40 C	GOES-East water vapor
Cloud-cleared brightness temp	GOES-East water vapor
Climatological TC formation probability	Dvorak dataset / HURDAT / Best Track
Distance to existing TC	Dvorak dataset / HURDAT / Best Track
Shear direction	GFS analyses
Potential intensity	GFS analyses / Reynold's weekly SST
200-mb temperature	GFS analyses
700-500 mb relative humidity	GFS analyses
700-850 mb temp advection	GFS analyses
Total Precipitable Water	Microwave Satellite-derived
Dvorak T-number	Dvorak dataset
Dvorak CI number	Dvorak dataset

TCGI Predictor Development

- **Methodology (Kaplan et al. 2010, RI Index)**

    1. Utilize potential TCGI predictors identified (e.g. TCFP, TPW, and Dvorak T-number/CI value;

    2. Magnitude of each predictor >> evaluated for (0-48 h & 0-120 h) for all cases (2001-2010 Atlantic basin developmental dataset);

    3. Sensitivity tests >> determine which combination of predictors yields the most skillful genesis probability forecasts (0-48 h, 0-120 h) >> linear discriminant analysis;

    4. TCGI (0-48 h and 0-120 h) >> real-time tests for Atlantic basin systems that NHC designates as "Invests";

Timeline: Year-2

- **June-Nov 2012**:
  -Begin sensitivity testing for optimal combination of TCGI predictors (0-48h & 0-120h)

- **Dec 2012**:
  -Develop code for running real-time TCGI (0-48 h and 0-120 h)

- **March 2013**:
  -Present year-2 results at IHC

- **June-Aug 2013**:
  -TCGI real-time tests (0-48 and 0-120 h)
  -utilize NESDIS computers at CIRA (output via ftp site) or JHT computers;

- **Aug 2013**:
  -Final TCGI code will be made available (if project is accepted)
  -possible installation on the IBM >> operational SHIPS/LGEM guidance suite

Possible TCGI Output

```
        *    ATLANTIC SHIPS INTENSITY FORECAST        *
        * GOES AVAILABLE,        OHC AVAILABLE         *
        *      INVEST  AL972011   08/20/11  12 UTC     *

TIME (HR)         0     6    12    18    24    36    48    60    72    84    96   108   120
```

```
   ** 2011 ATLANTIC TCGI AL972011      INVEST 08/20/11  12 UTC **
```

DVORAK CI NUM	:	1.0 Range: 0.5 to 2.0 Scaled/Wgted Val:	0.7/ 2.2
850-200 MB SHEAR (KT)	:	5.7 Range: 26.2 to 3.2 Scaled/Wgted Val:	0.9/ 1.7
STD DEV OF IR BR TEMP	:	20.9 Range: 50.0 to 15.2 Scaled/Wgted Val:	0.4/ 0.9
D200 (10**7s-1)	:	41.8 Range:-21.0 to 165.0 Scaled/Wgted Val:	0.3/ 20.7
850 MB VOR (10**-6s-1)	:	30 Range: 10.0 to 100. Scaled/Wgted Val:	1.0/ 1.1
TPW (MM)	:	50.5 Range: 30.0 to 70.0 Scaled/Wgted Val:	0.6/ 0.7
Heat content (KJ/cm2)	:	72.2 Range: 0.0 to 130.0 Scaled/Wgted Val:	0.6/ 0.0
% area w/pixels <-30 C	:	45.0 Range: 17.0 to 80.0 Scaled/Wgted Val:	0.6/ 0.2

```
Prob of Genesis (0-48 hr)   =    70% is   4.7 times the sample mean (15.0%)
Prob of Genesis (0-120 hr)  =    90% is   3.0 times the sample mean (30.0%)
```

```
LONG(DEG W)     34.9 XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X XXX.X
STM SPEED (KT)    18    18    18    18    16    13    11    10    10    10     9     8     7
HEAT CONTENT      68    76    66    70    81    70    69    84    77    56    23    48    33

FORECAST TRACK FROM OFPI      INITIAL HEADING/SPEED (DEG/KT):275/ 18      CX,CY: -17/  2
T-12 MAX WIND:  25            PRESSURE OF STEERING LEVEL (MB):  604  (MEAN=623)
GOES IR BRIGHTNESS TEMP. STD DEV.  50-200 KM RAD:  20.9 (MEAN=14.5)
% GOES IR PIXELS WITH T < -20 C    50-200 KM RAD:  71.0 (MEAN=65.0)
```

Conclusions & Future Work

- Tropical Cyclone Genesis Index
    - -disturbance-centric/objective/probabilistic
    - -0-48 hr and 0-120 hr forecasts
    - -possible integration of a wide variety of predictors
    - -possible inclusion into the SHIPS real-time suite

- Year-1 Efforts
    - -Dvorak database (tracks & intensity) completed
    - -Continuous "Invest Best Track" nearly completed
    - -Testing of TCFP, TPW, Dvorak T-number/CI Value predictors for TCGI database beginning in the coming weeks

- Year-1/2 Efforts
    - -Sensitivity testing for optimal combination of TCGI predictors (0- 48h & 0-120h): June-Nov 2012
    - -real-time code development >> late 2012

Conclusions & Future Work (cont'd)

- Future integration of additional predictors
    - -microwave imagery (e.g. 37 & 85 GHz)
    - -ensemble model information
    - -automated scheme for identifying Invests
    - -expand TCGI to other basins