October 25, 2014

Atlantic Basin Seasonal Hurricane Prediction

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Outline

- Introduction
- Atlantic Basin Hurricane Multi-Decadal Variability
- 2013 Atlantic Basin Seasonal Forecast Bust
- 2014 Atlantic Basin Hurricane Prediction

1 JUNE 1982

"There is no way to tell how active the coming Atlantic hurricane season is going to be."

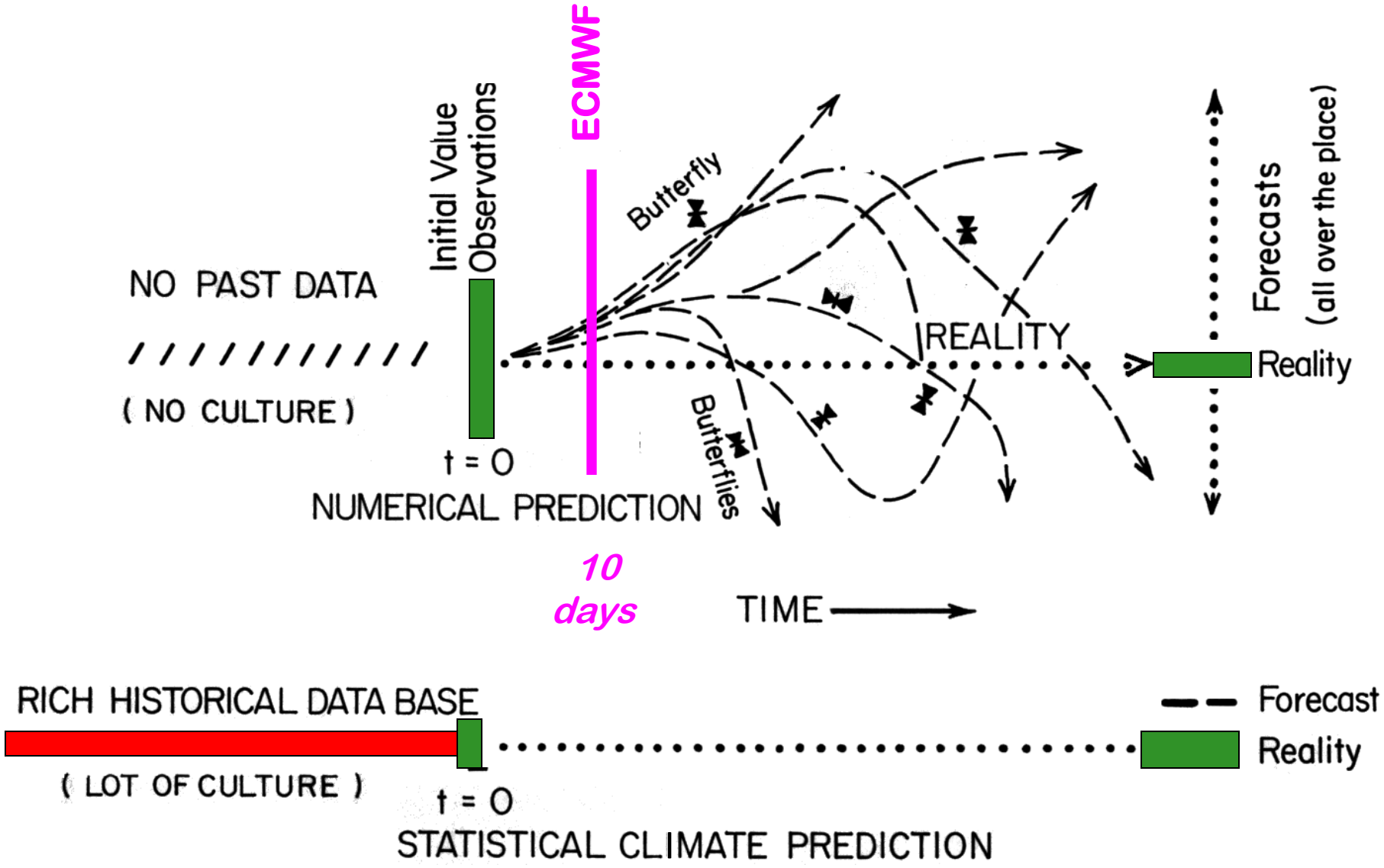
-Neil Frank, Director of NHC

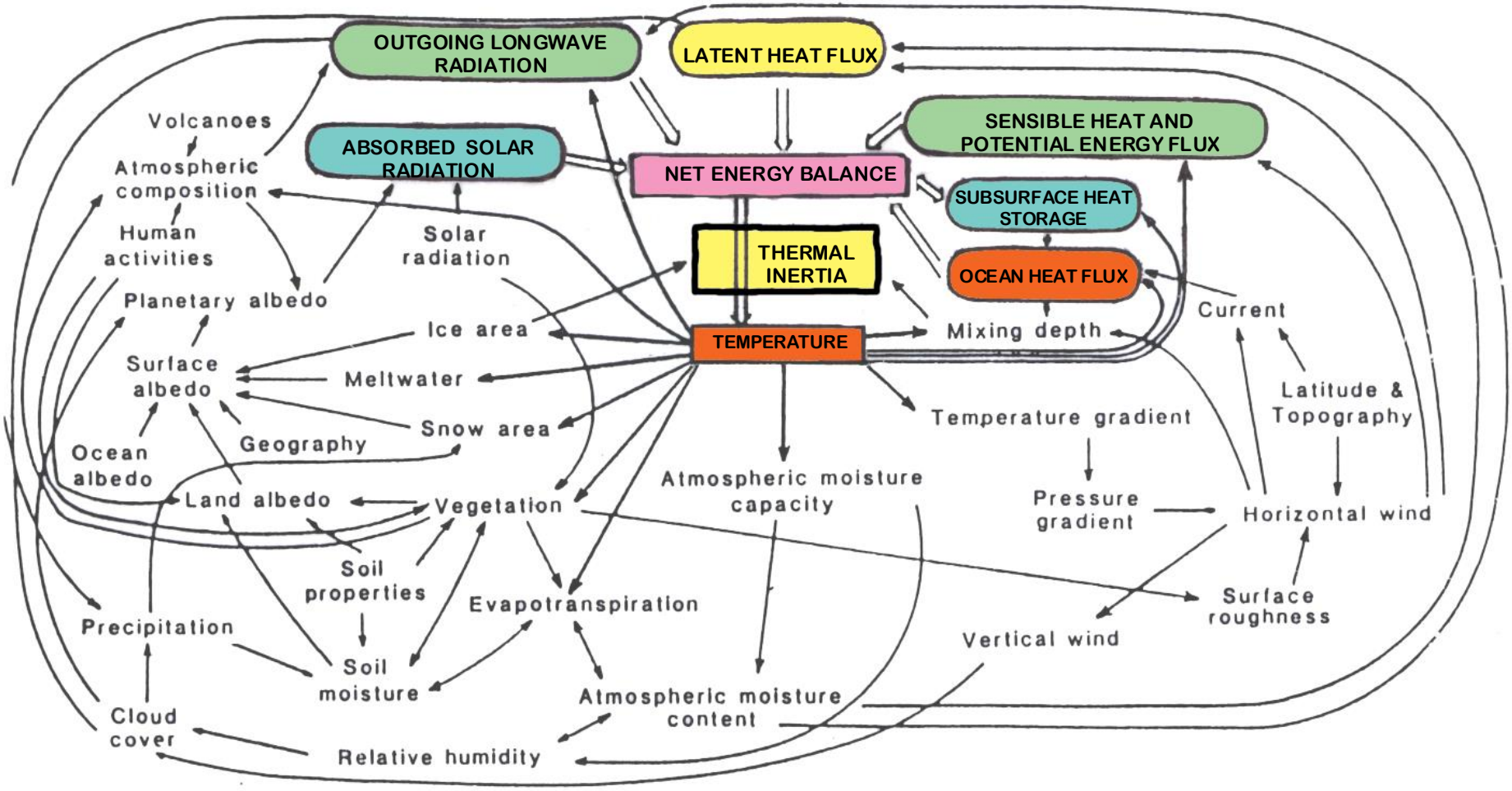
“It's tough to make predictions, especially about the future”

HOWEVER…

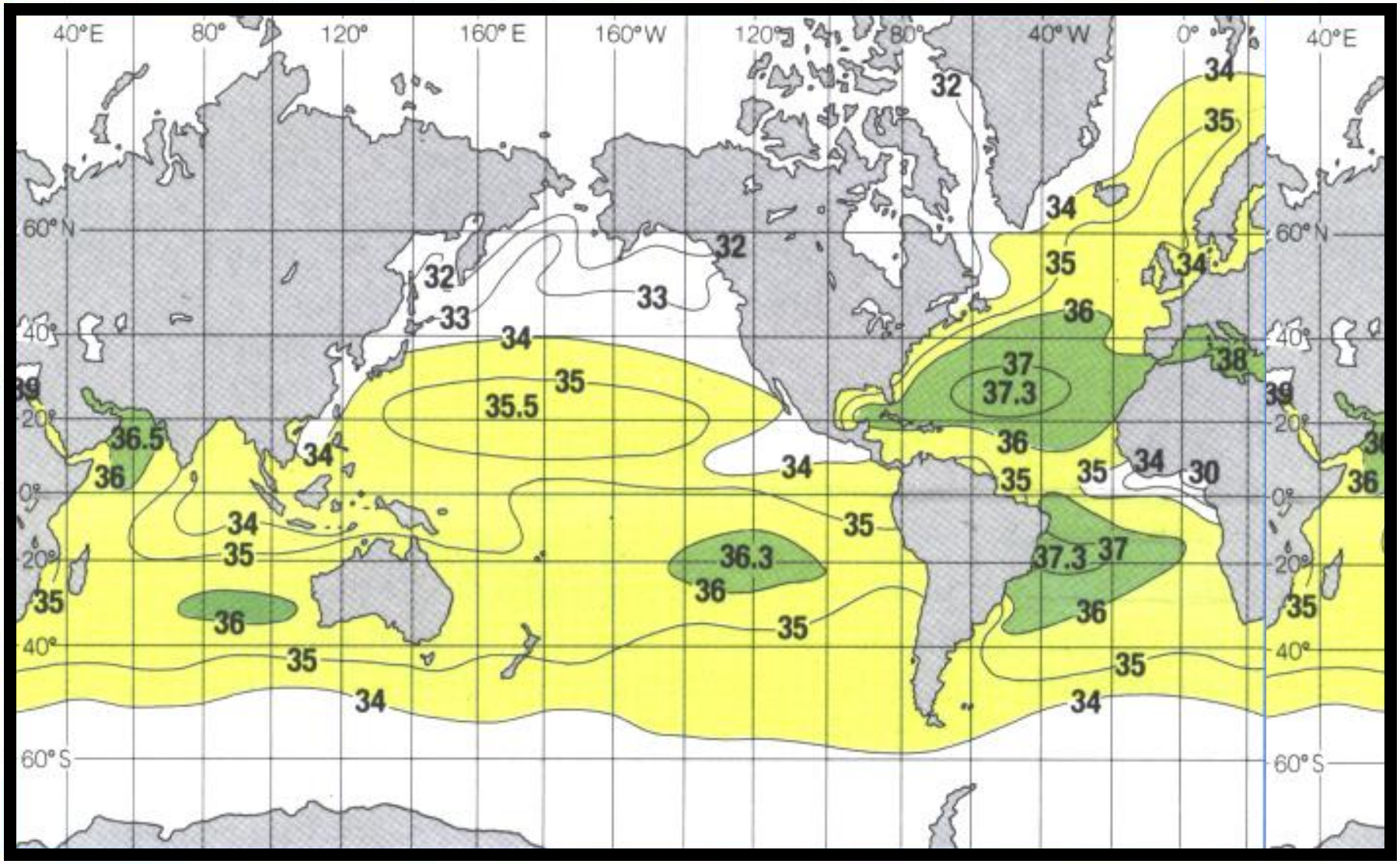
“You can see a lot by looking”

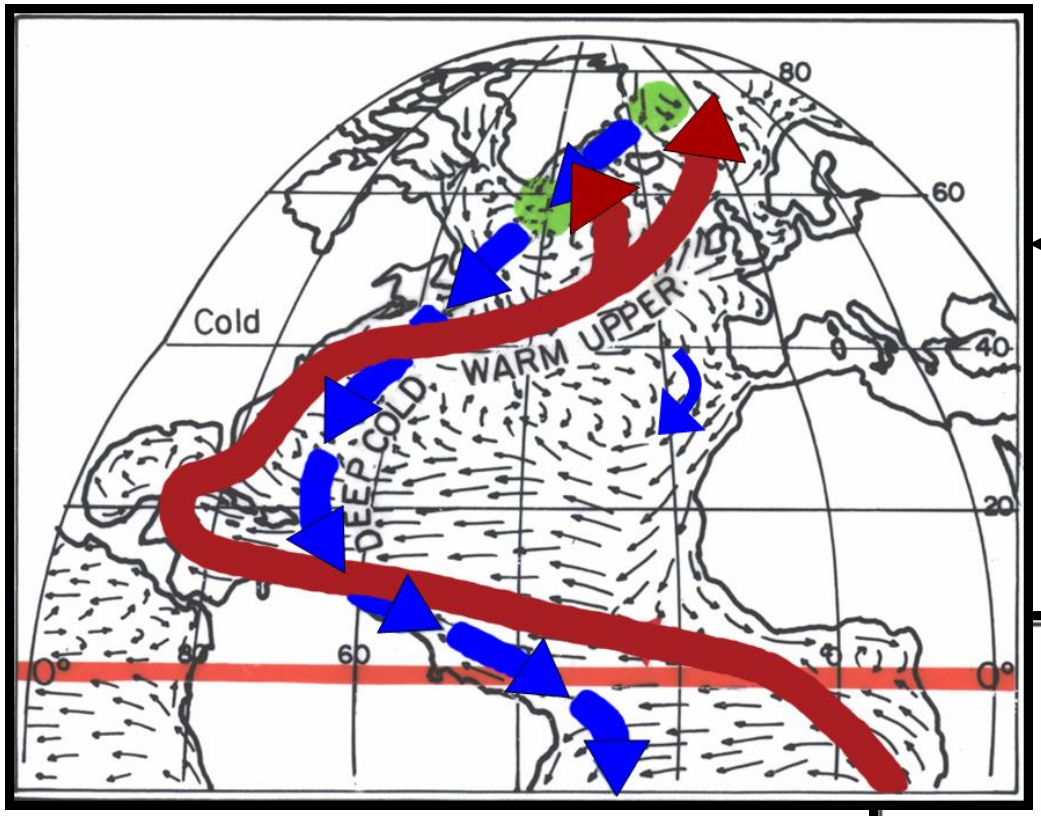
Yogi Berra


ECMWF
Initial Value Observations
Butterfly
NO PAST DATA
(NO CULTURE)
t = 0
NUMERICAL PREDICTION
Butterflies
REALITY
Forecasts (all over the place)
Reality
10 days
TIME
RICH HISTORICAL DATA BASE
(LOT OF CULTURE)
t = 0
STATISTICAL CLIMATE PREDICTION
Forecast
Reality



Flow diagram for climate modeling, showing feedback loops. From Robock (1985).


40°E
80°
120°
160°E
160°W
120°
80°
40°W
0°
40°E
60°N
40°
20°
0°
20°
40°
60°S
32
34
35
34
32
32
33
33
34
35
35.5
34
36.5
36
34
34
35
36.3
36
35
36
35
34
32
34
35
36
37
37.3
38
39
36
35
34
30
37.3
37
36
35
35
34



THC *(or AMO)*

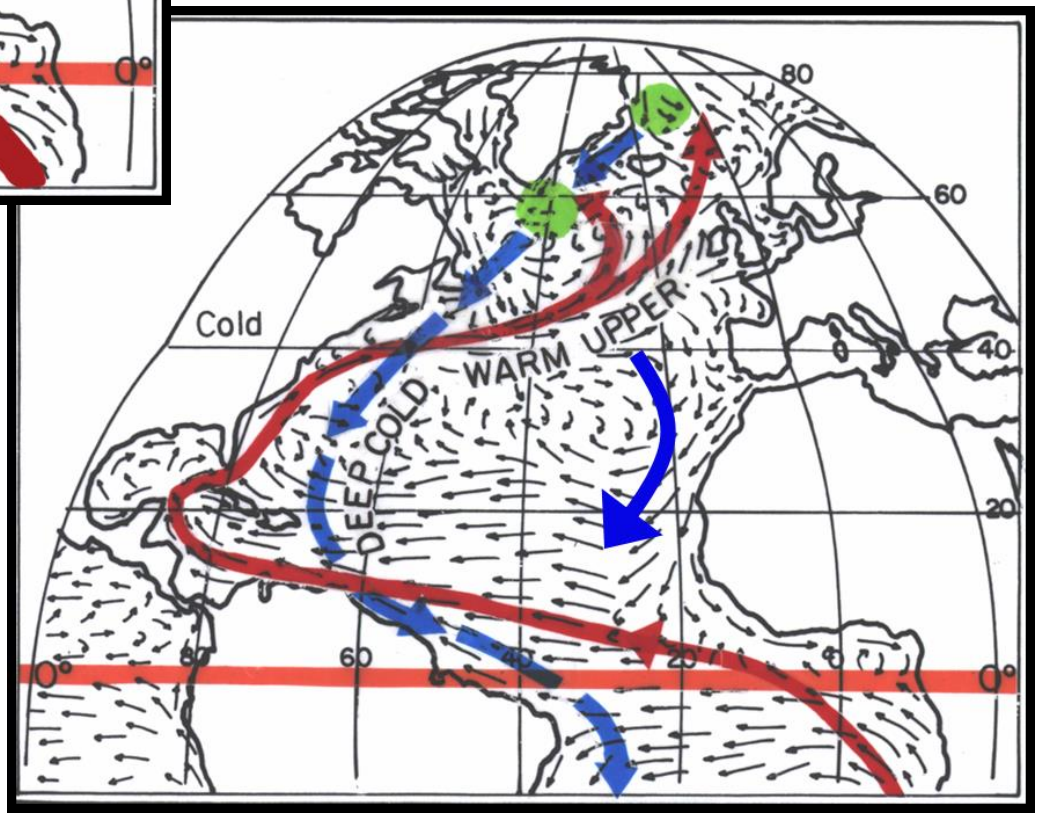
←

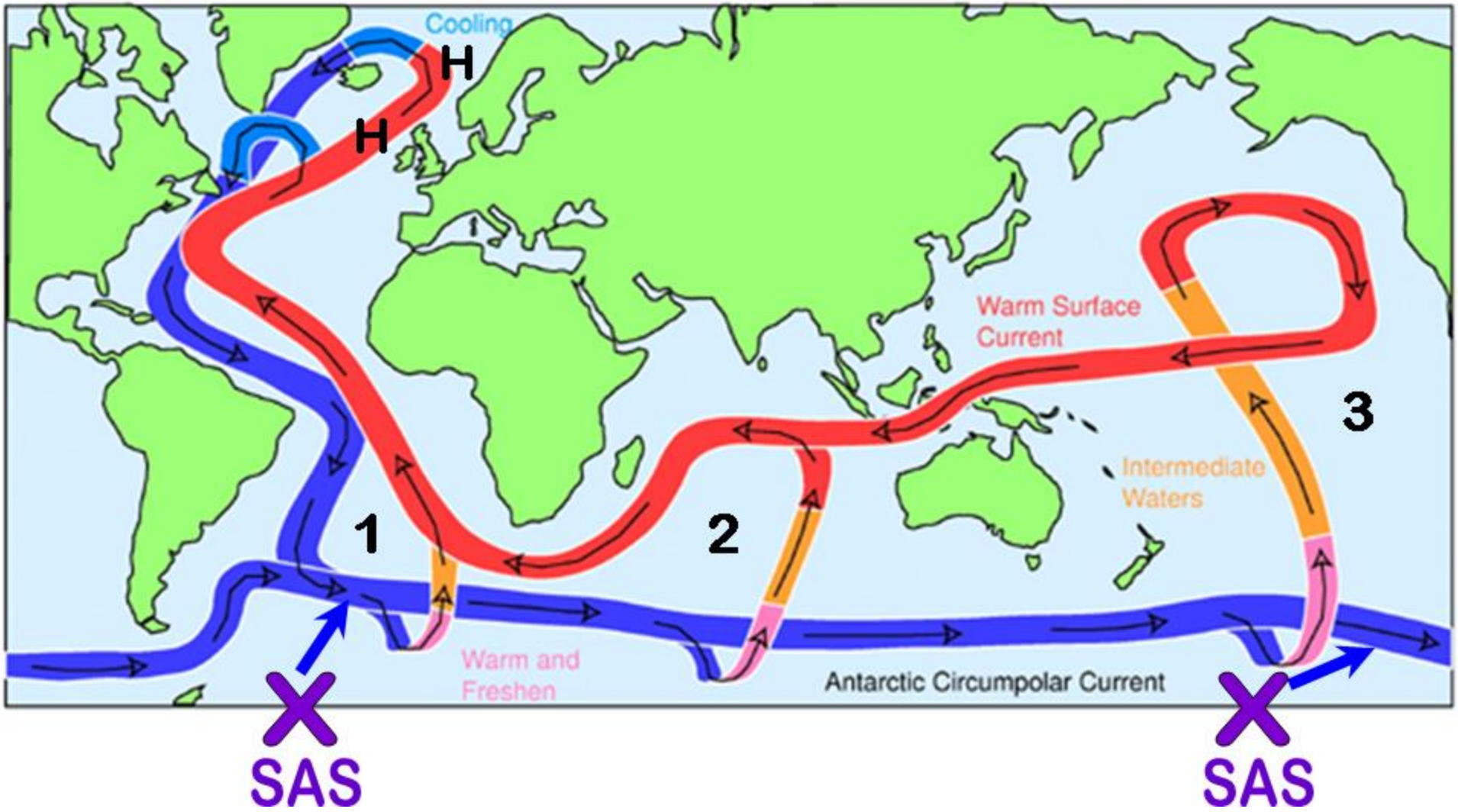
STRONG

THC *(or AMO)*

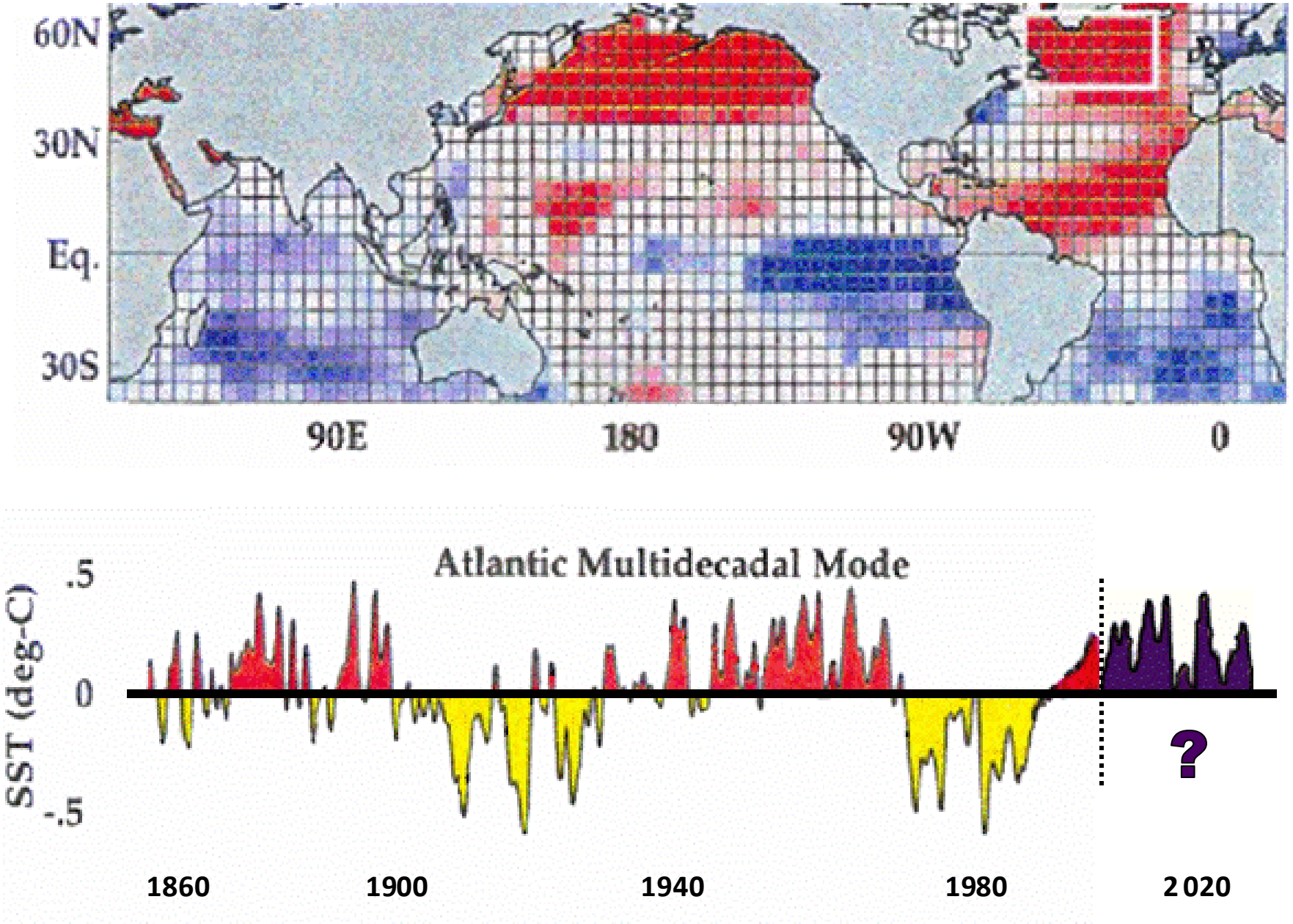
→

WEAK

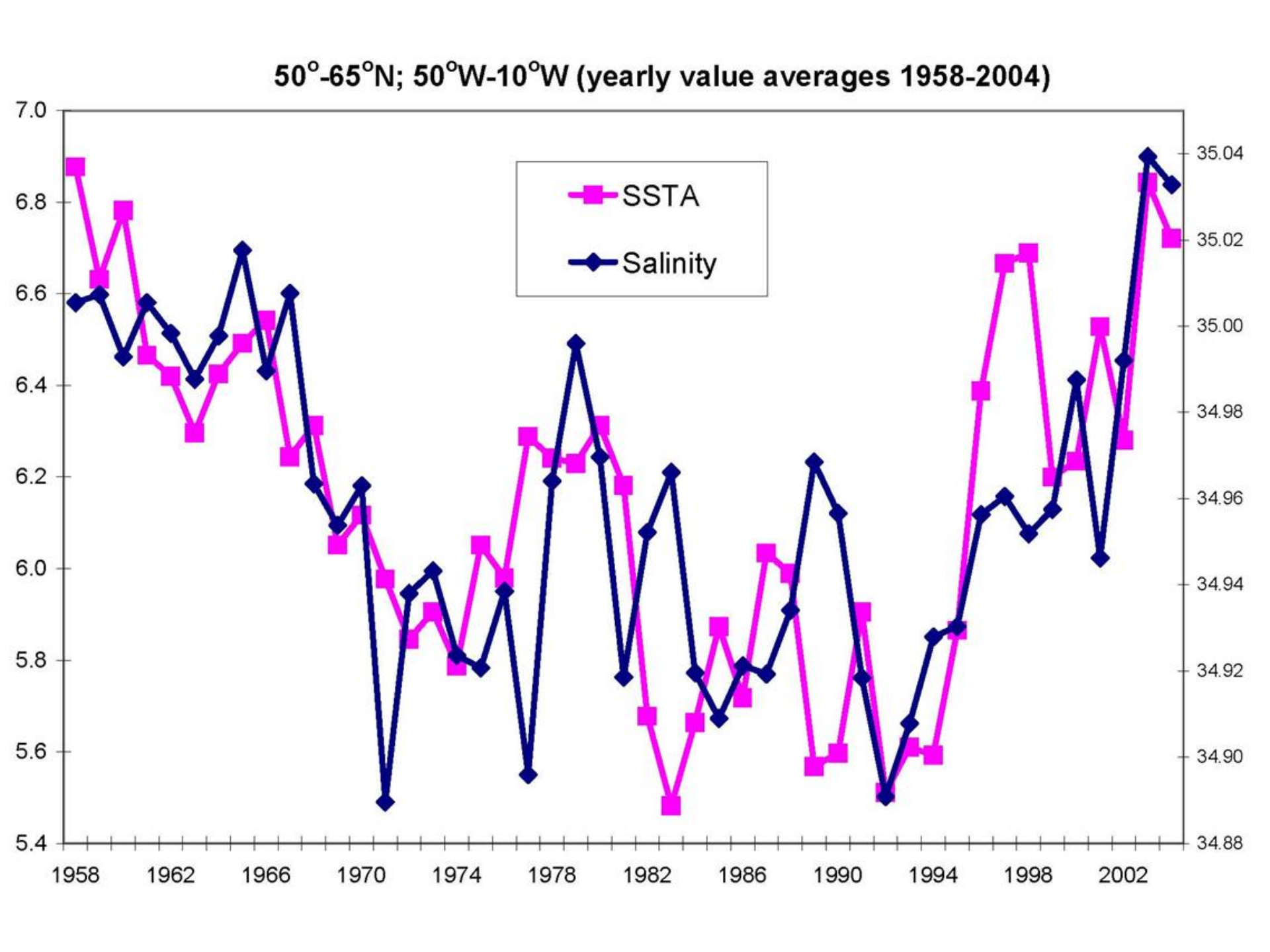


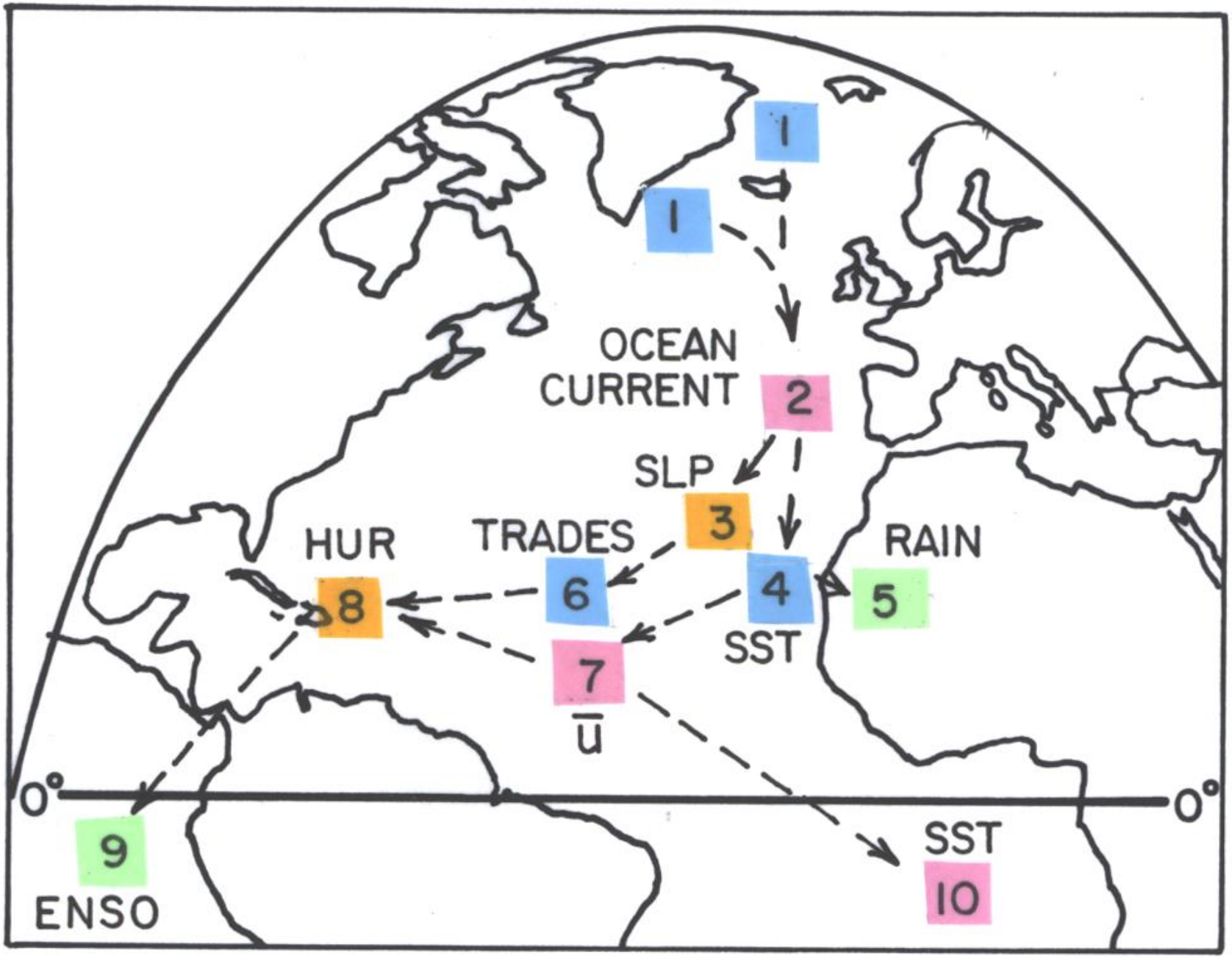


Courtesy of John Marshall (MIT)

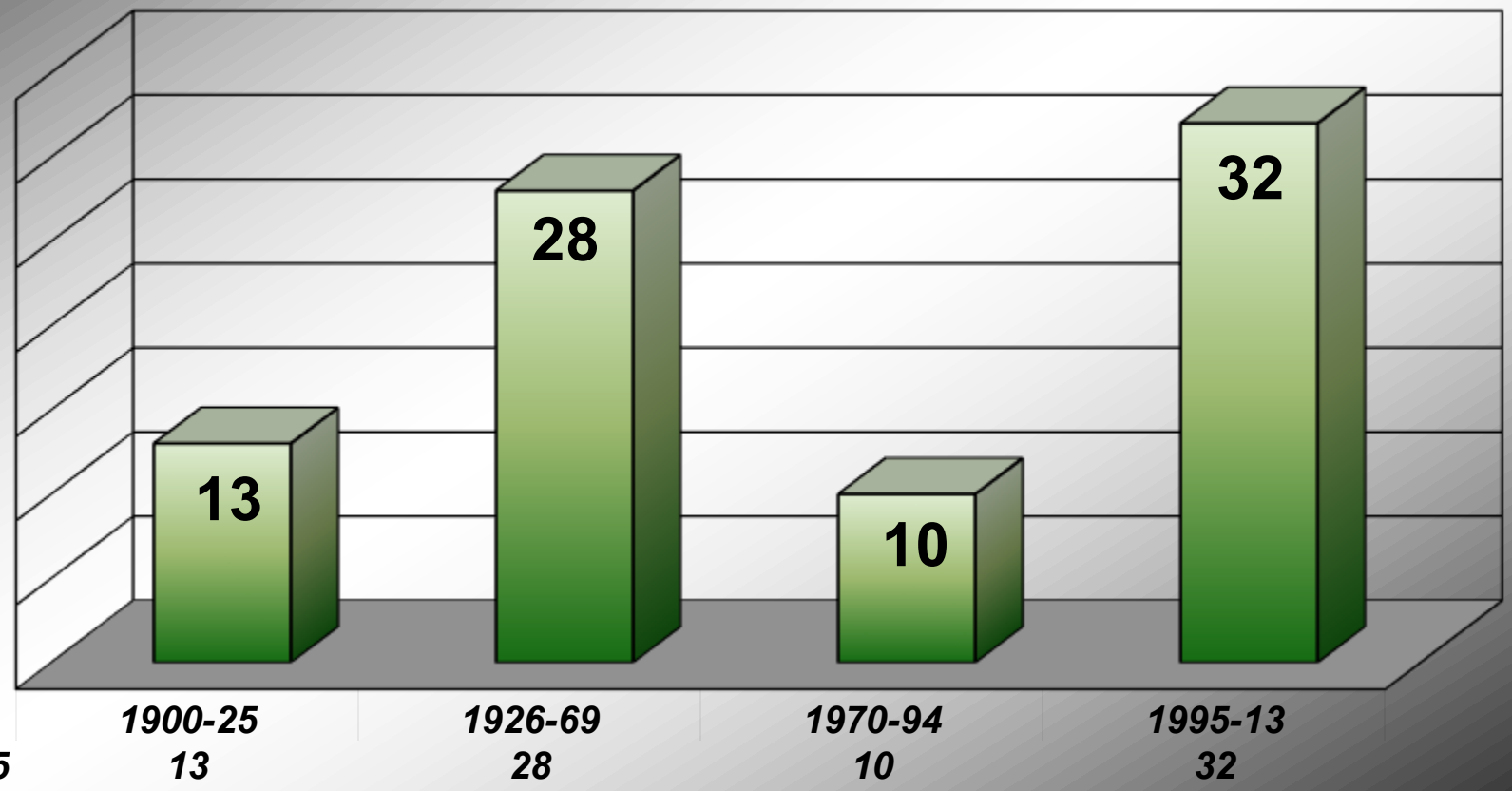


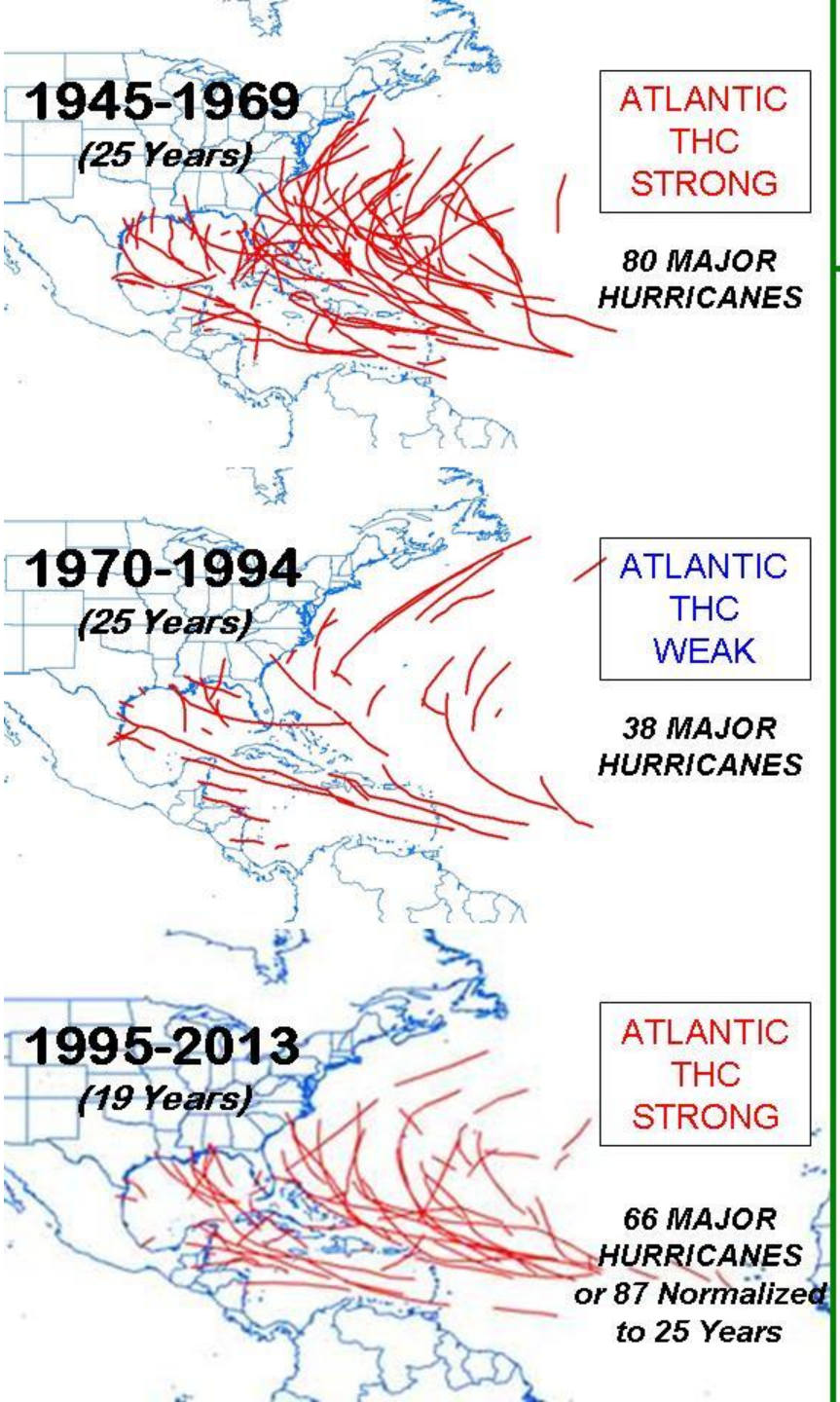
Goldenberg et al. (2001)


50°-65°N; 50°W-10°W (yearly value averages 1958-2004)
SSTA
Salinity
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
5.4
35.04
35.02
35.00
34.98
34.96
34.94
34.92
34.90
34.88
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002


1
1
OCEAN
CURRENT
2
SLP
3
HUR
TRADES
RAIN
8
6
4
5
SST
7
ū
0°
0°
9
ENSO
SST
10

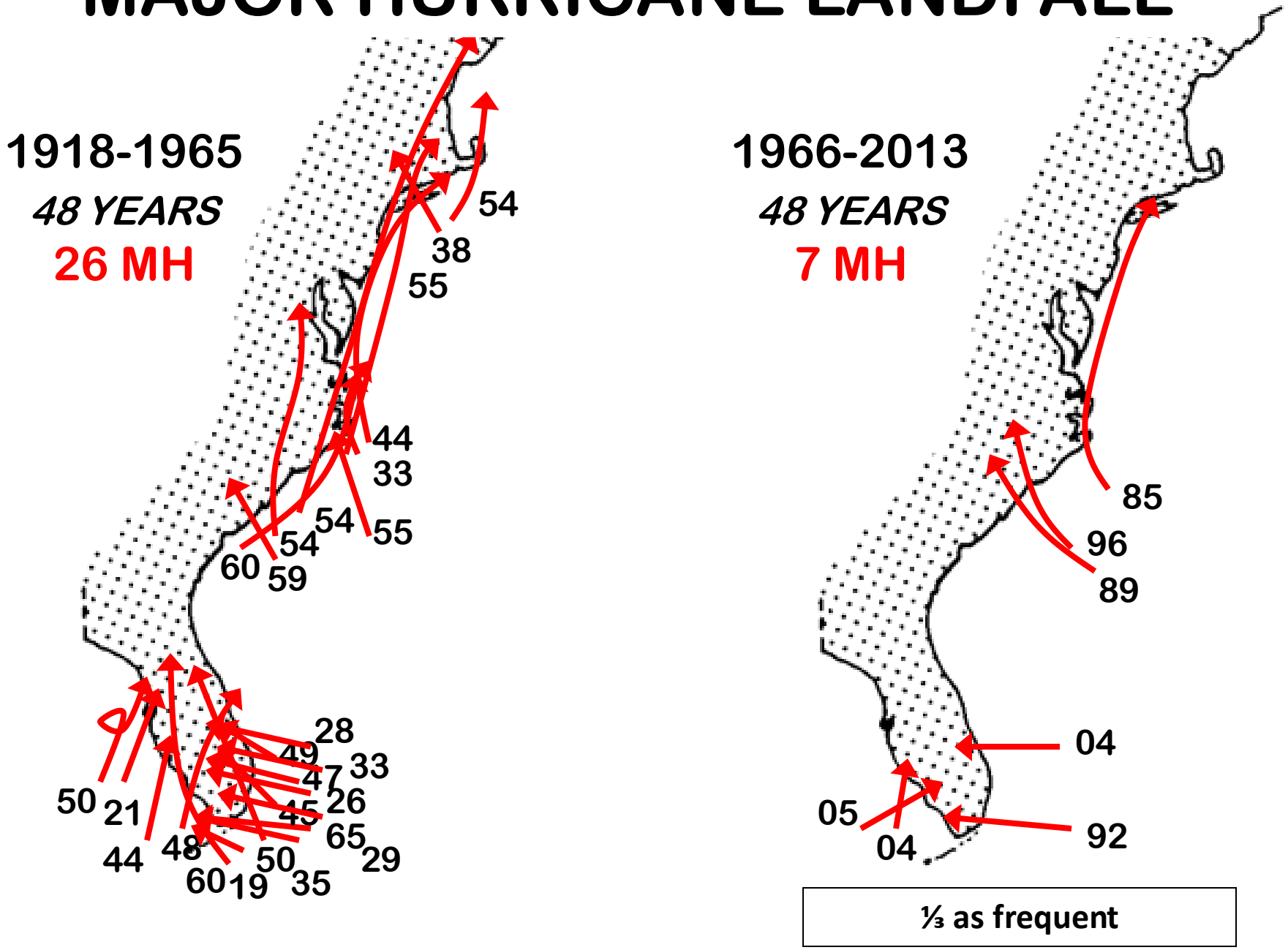
Annual Number of 6 Hour Periods for Cat 3-4-5 Hurricanes

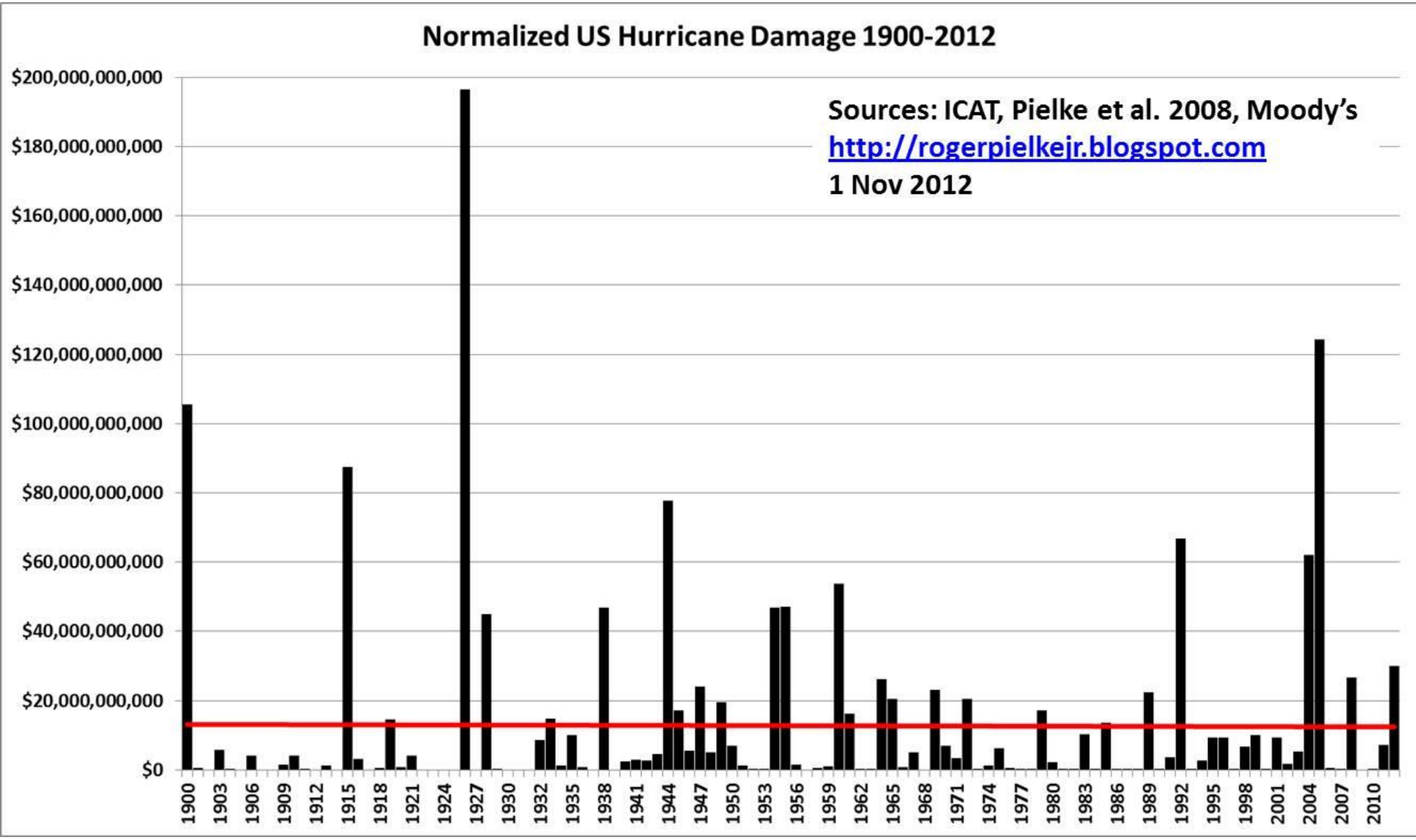




RATIO RELATIVE TO 1970-1994	
# MH	# MHD
2.1	3.2
1.0	1.0
2.3	3.2

MAJOR HURRICANE LANDFALL

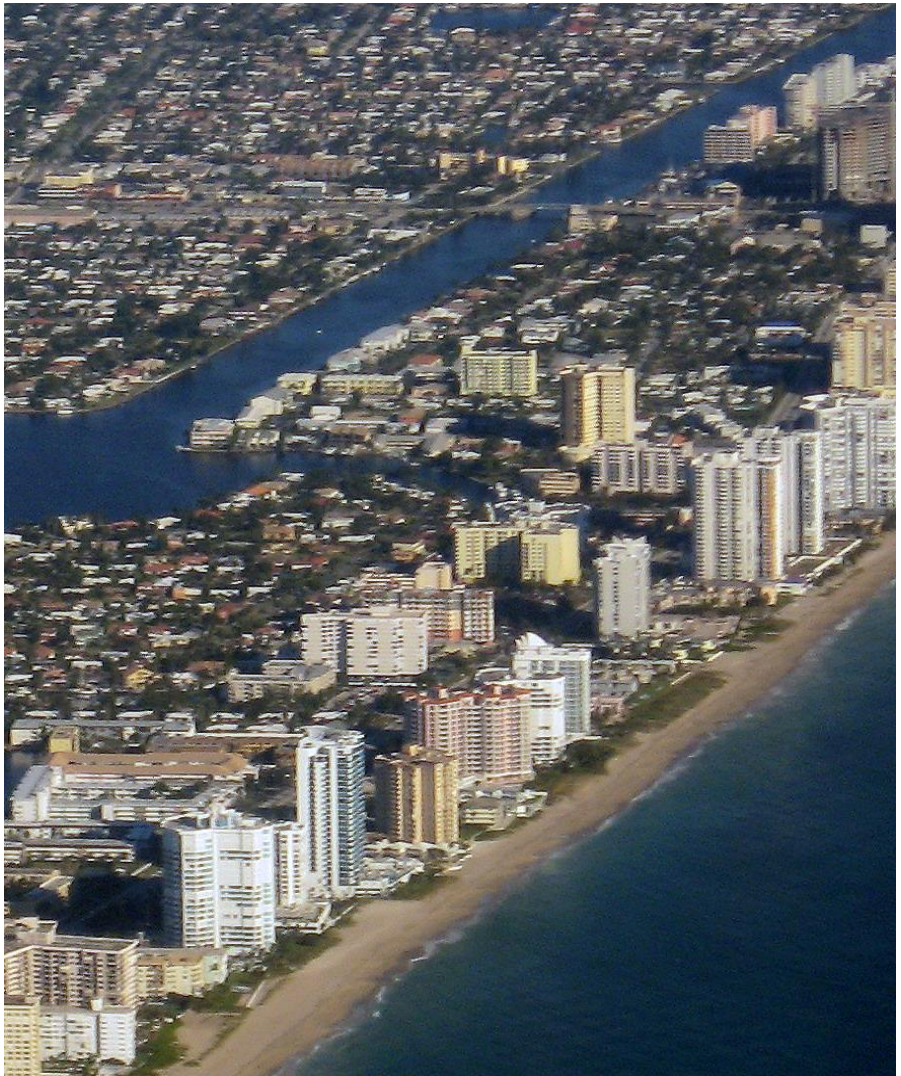


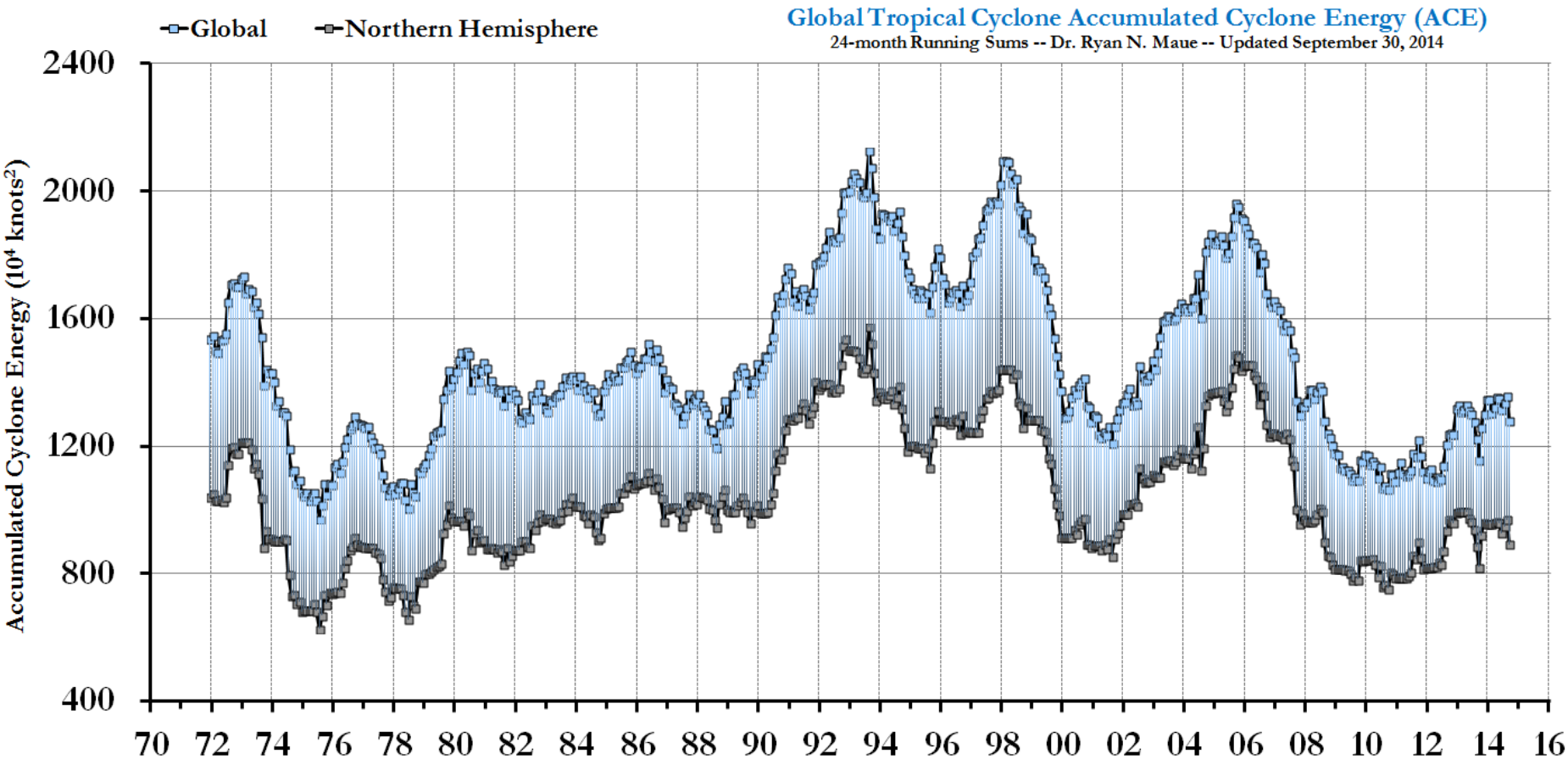

Normalized US Hurricane Damage 1900-2012
Sources: ICAT, Pielke et al. 2008, Moody's
http://rogerpielkejr.blogspot.com
1 Nov 2012
$200,000,000,000
$180,000,000,000
$160,000,000,000
$140,000,000,000
$120,000,000,000
$100,000,000,000
$80,000,000,000
$60,000,000,000
$40,000,000,000
$20,000,000,000
$0
1900
1903
1906
1909
1912
1915
1918
1921
1924
1927
1930
1932
1935
1938
1941
1944
1947
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010

1926 Great Miami Hurricane - $165 Billion Insured Damage

1926

2006




Global
Northern Hemisphere
Global Tropical Cyclone Accumulated Cyclone Energy (ACE)
24-month Running Sums -- Dr. Ryan N. Maue -- Updated September 30, 2014
Accumulated Cyclone Energy (10⁴ knots²)
2400
2000
1600
1200
800
400
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04 06 08 10 12 14 16

2008	7 Dec. 2007	Update 9 April	Update 3 June	Update 5 August	Obs.
Hurricanes	7	8	8	9	8
Named Storms	13	15	15	17	16
Hurricane Days	30	40	40	45	29.50
Named Storm Days	60	80	80	90	84.75
Major Hurricanes	3	4	4	5	5
Major Hurricane Days	6	9	9	11	8.50
Accumulated Cyclone Energy	115	150	150	175	146
Net Tropical Cyclone Activity	125	160	160	190	164

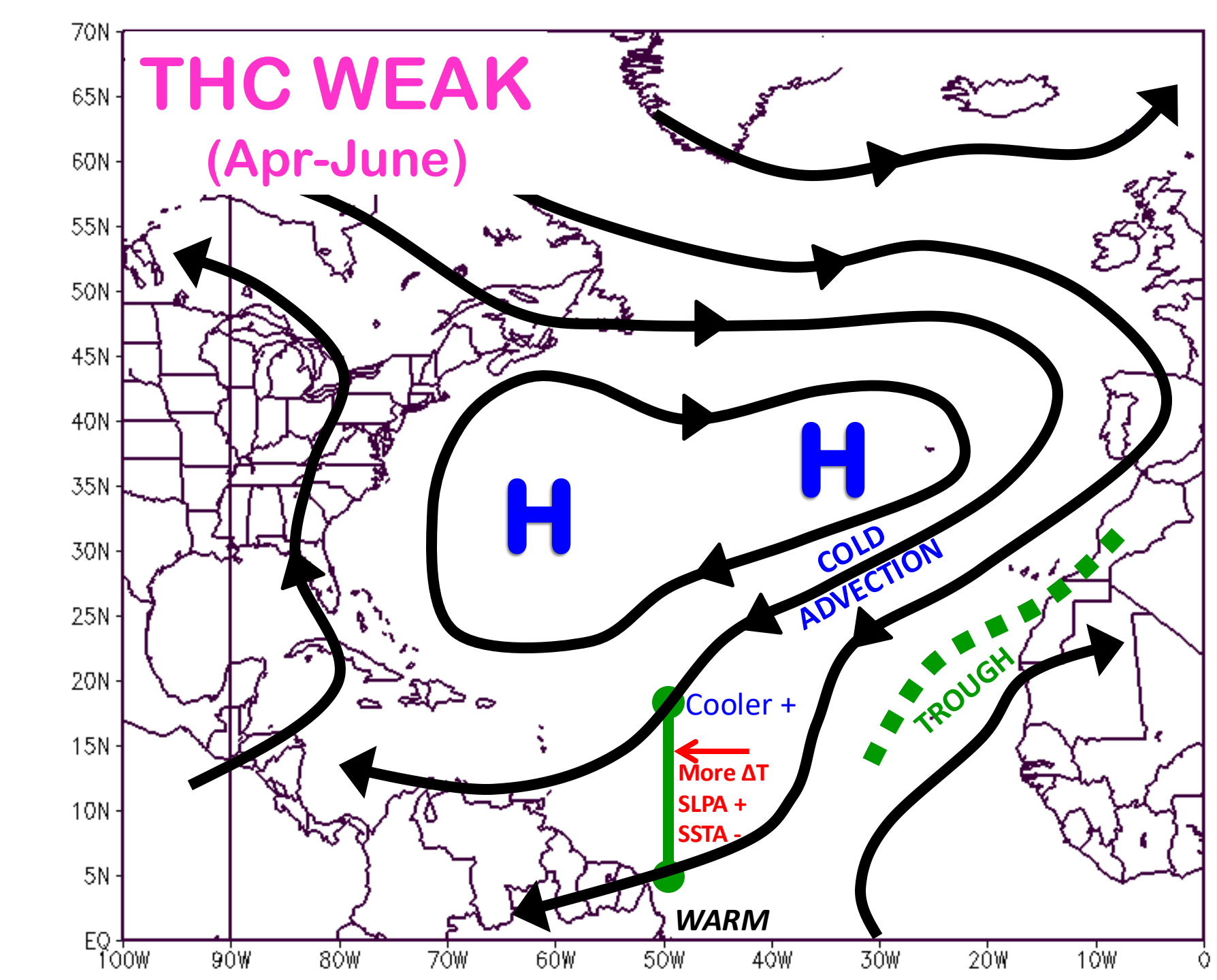
2010	9 Dec. 2009	Update 7 April	Update 2 June	Update 4 August	Obs.
Hurricanes	6-8	8	10	10	12
Named Storms	11-16	15	18	18	19
Hurricane Days	24-39	35	40	40	37.50
Named Storm Days	51-75	75	90	90	88.25
Major Hurricanes	3-5	4	5	5	5
Major Hurricane Days	6-12	10	13	13	11
Accumulated Cyclone Energy	100-162	150	185	185	163
Net Tropical Cyclone Activity	108-172	160	195	195	195

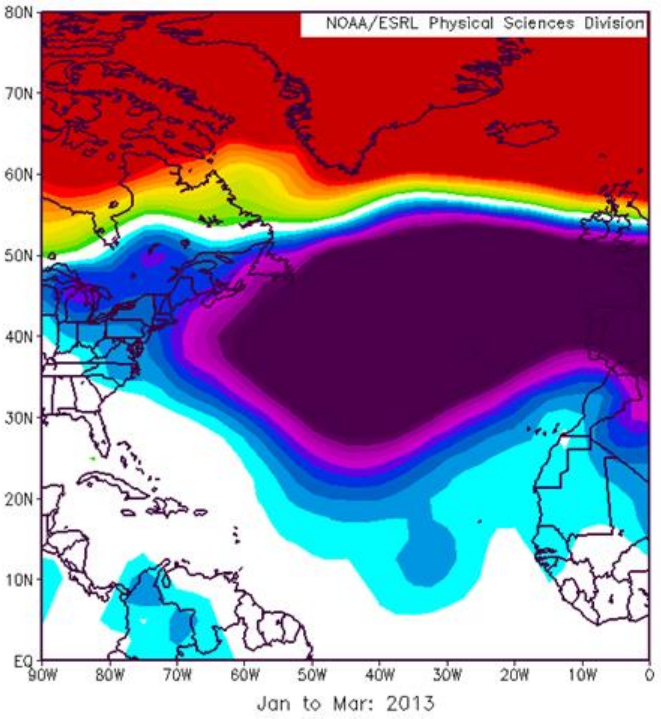
DISASTER

2013	10 April	Update 3 June	Update 2 August	Obs.
Hurricanes	9	9	8	2
Named Storms	18	18	18	14
Hurricane Days	40	40	35	3.25
Named Storm Days	95	95	84.25	42.25
Major Hurricanes	4	4	3	0
Major Hurricane Days	9	9	7	0
Accumulated Cyclone Energy	165	165	142	36
Net Tropical Cyclone Activity	175	175	150	47

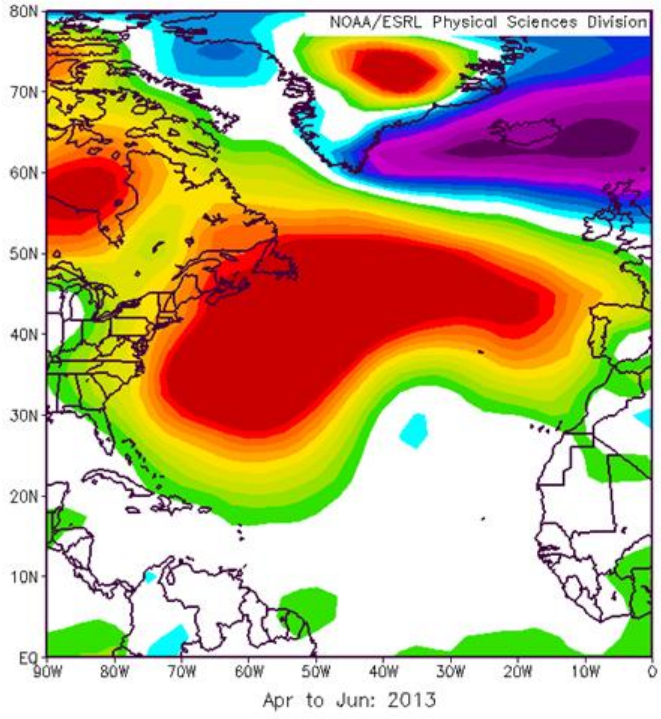
"The best laid schemes of mice and men sometimes go awry"

-- R. Burns

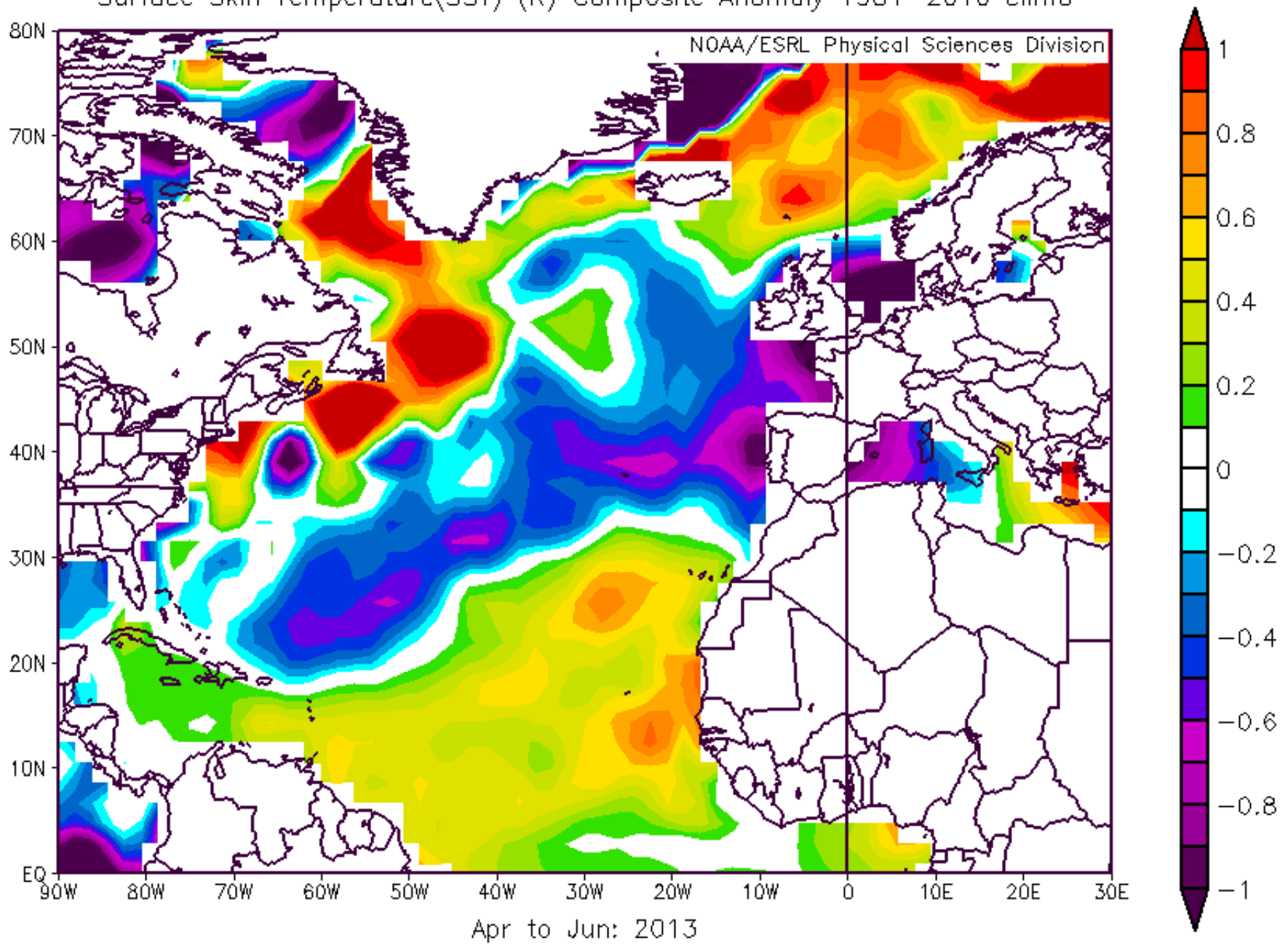

THC WEAK
(Apr-June)
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
H
H
COLD
ADVECTION
TROUGH
Cooler +
More ΔT
SLPA +
SSTA -
WARM



SLPA
Jan-Mar
2013



SLPA
Apr-Jun
2013


NCEP/NCAR Reanalysis
Surface Skin Temperature(SST) (K) Composite Anomaly 1981–2010 climo
NOAA/ESRL Physical Sciences Division
80N
70N
60N
50N
40N
30N
20N
10N
EQ
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
10E
20E
30E
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
Apr to Jun: 2013

Outlook for the 2014 Atlantic Hurricane Season

Phil Klotzbach

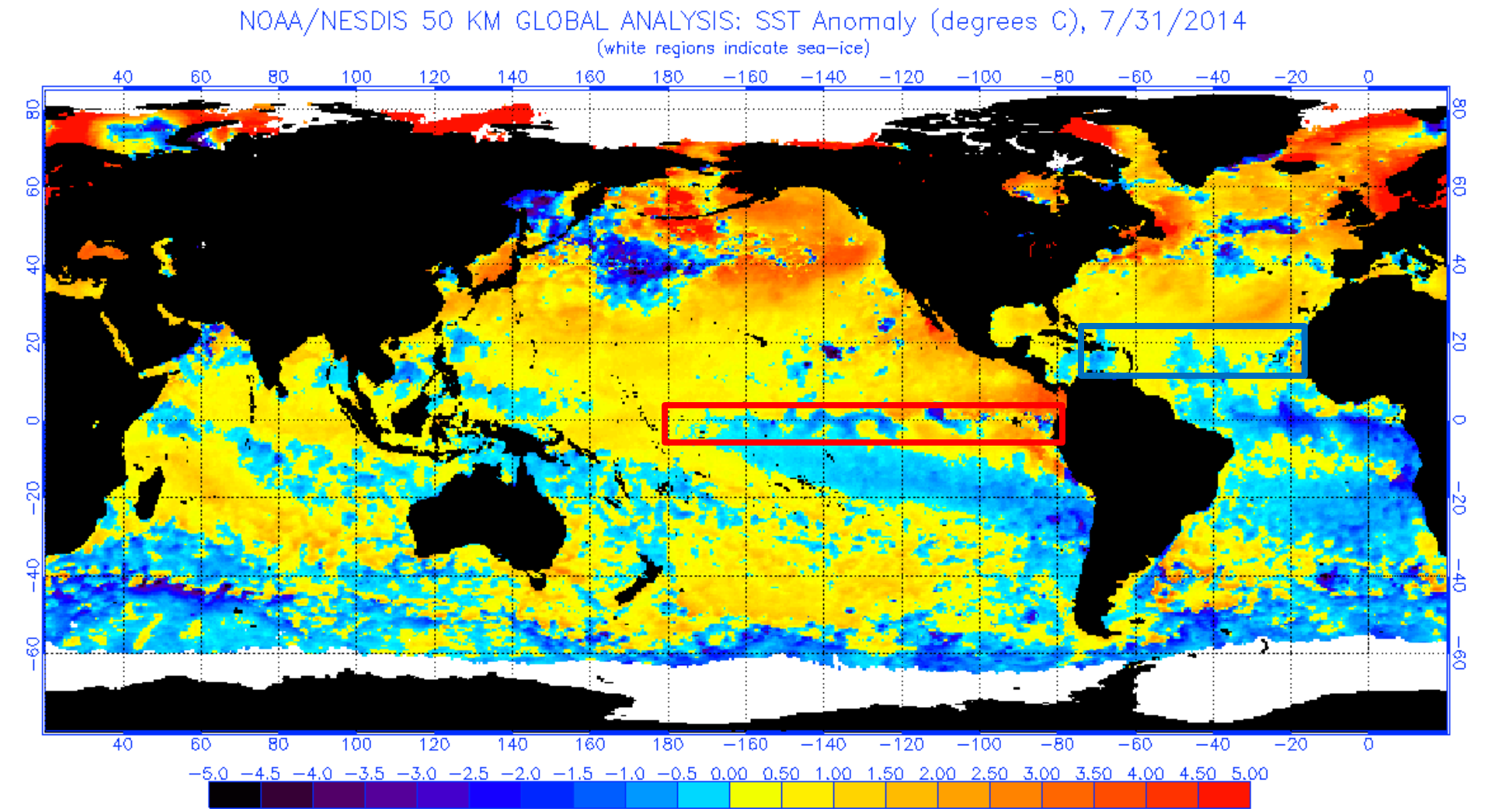
Department of Atmospheric Science

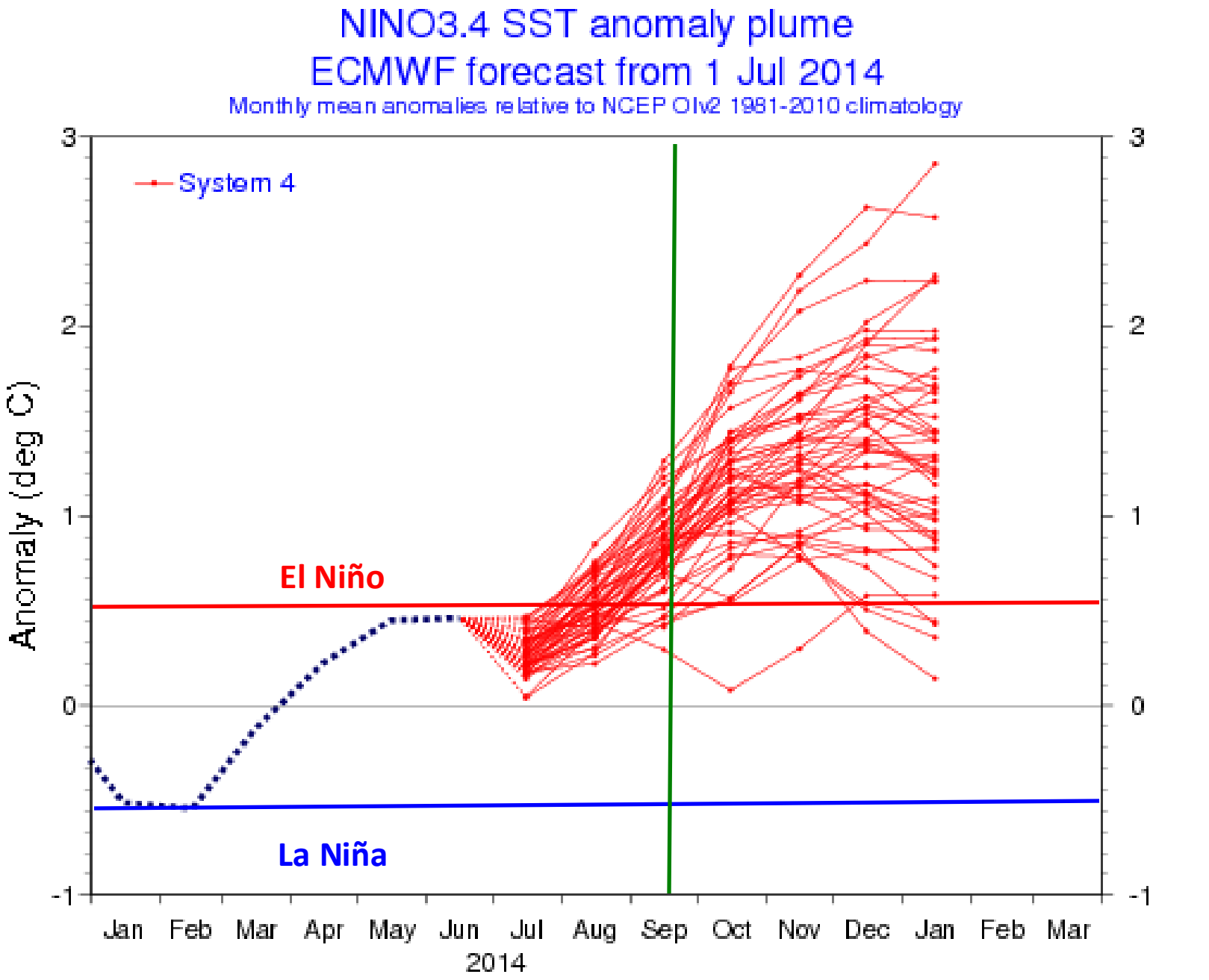
Colorado State University

All forecasts and verifications are available on our project's website:
http://tropical.atmos.colostate.edu

2014 FORECAST AS OF 1 AUGUST 2014

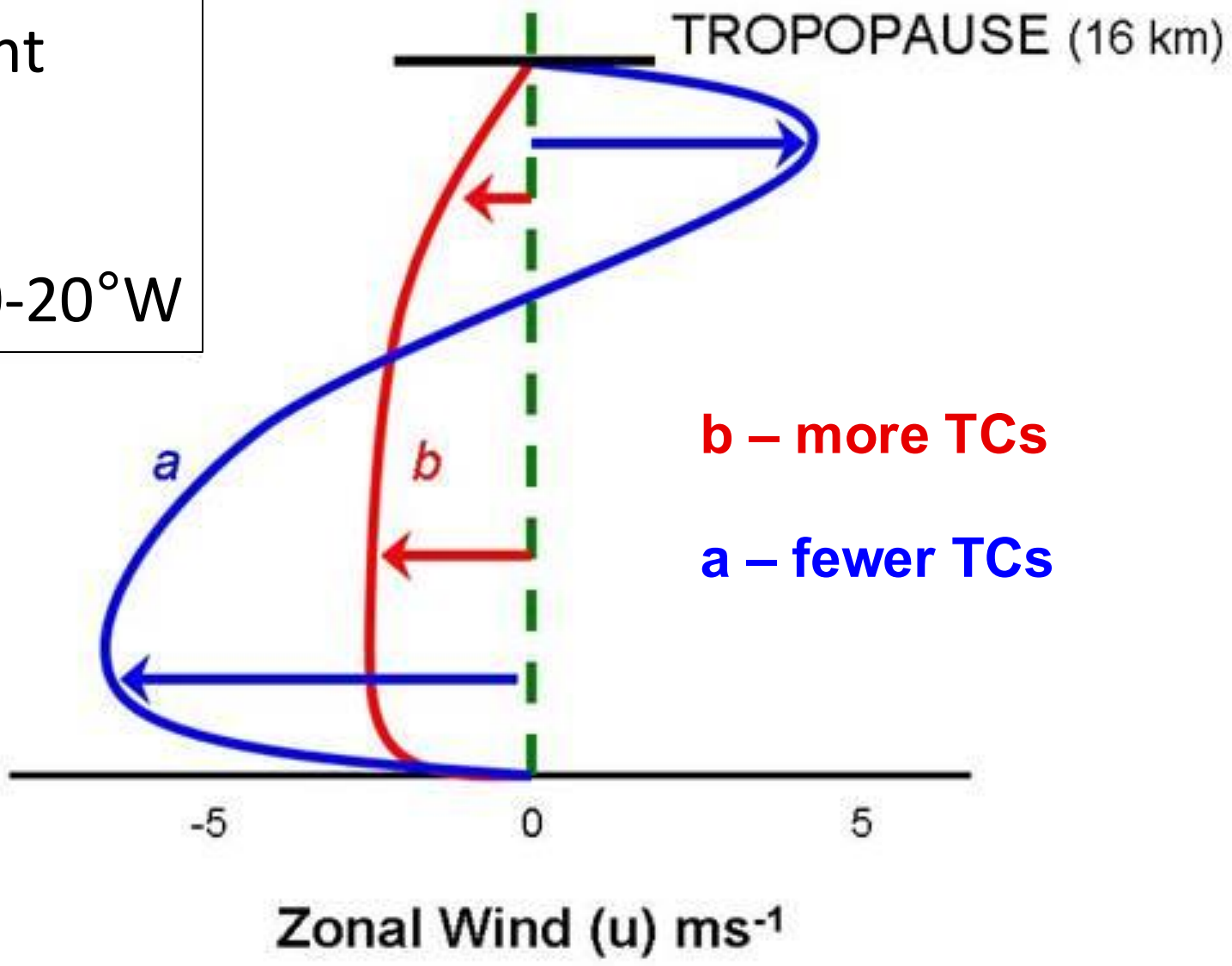
Forecast Parameter	Statistical Forecast	Final Forecast	1981-2010 Median
Named Storms (NS)	8.8	10	12.0
Named Storm Days (NSD)	35.1	40	60.1
Hurricanes (H)	4.9	4	6.5
Hurricane Days (HD)	12.9	15	21.3
Major Hurricanes (MH)	0.9	1	2.0
Major Hurricane Days (MHD)	1.1	3	3.9
Accumulated Cyclone Energy (ACE)	51	65	92
Net Tropical Cyclone Activity (NTC)	57	70	103


NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 7/31/2014
(white regions indicate sea-ice)
40 60 80 100 120 140 160 180 −160 −140 −120 −100 −80 −60 −40 −20 0
80 60 40 20 0 −20 −40 −60
−5.0 −4.5 −4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00

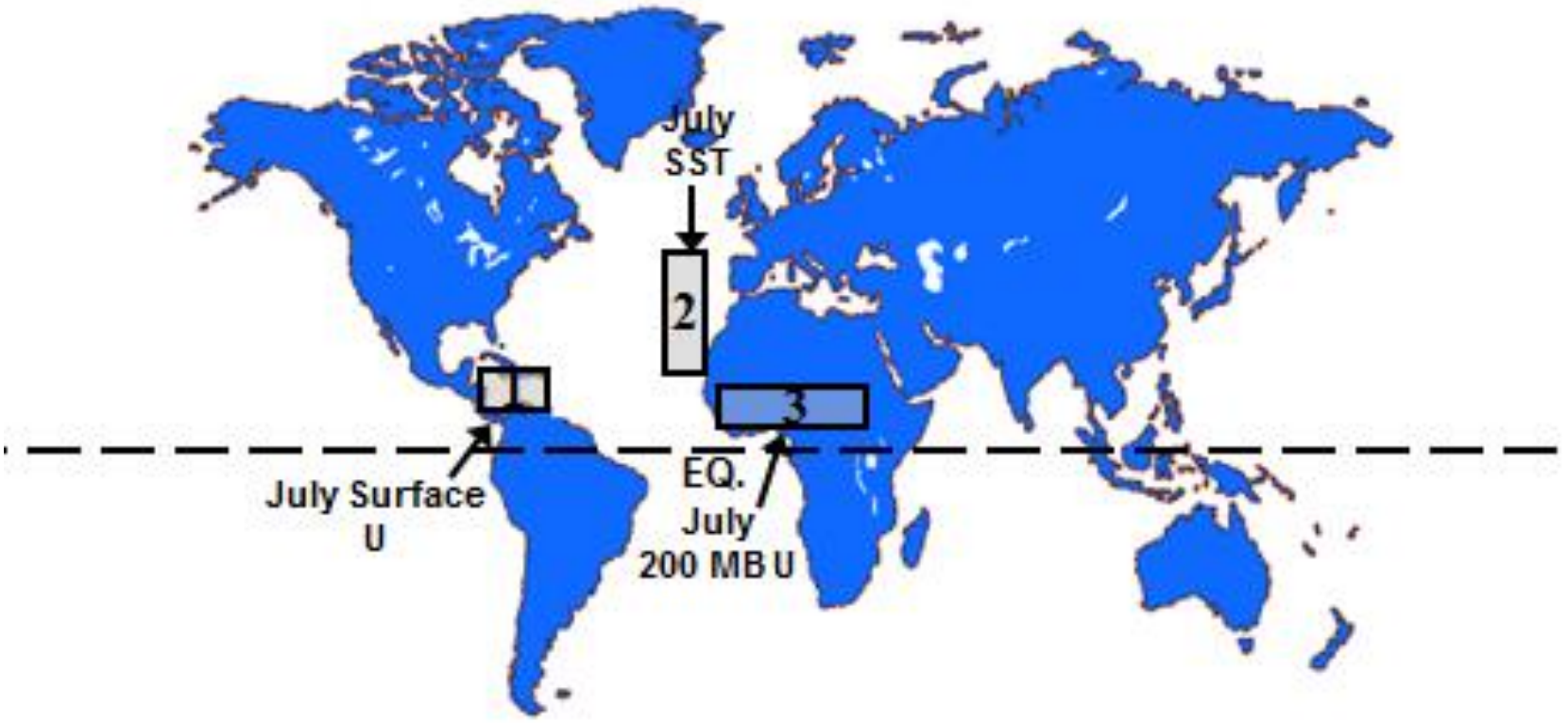

NINO3.4 SST anomaly plume
ECMWF forecast from 1 Jul 2014
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology
System 4
El Niño
La Niña
Anomaly (deg C)
3
2
1
0
-1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
2014

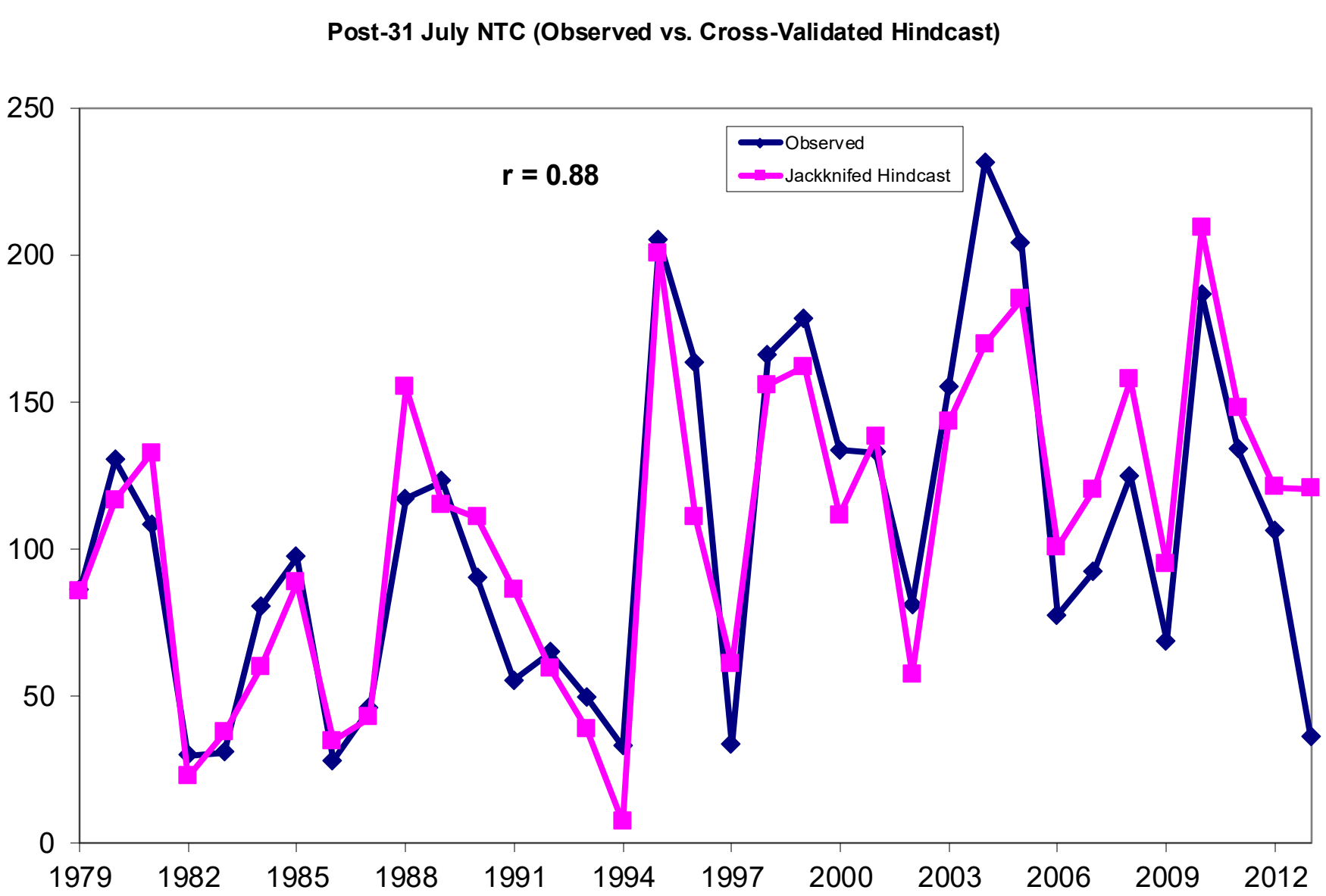
Vertical Wind Profile in the Main Development Region

10-20°N, 70-20°W



Post-31 July Seasonal Forecast Predictors



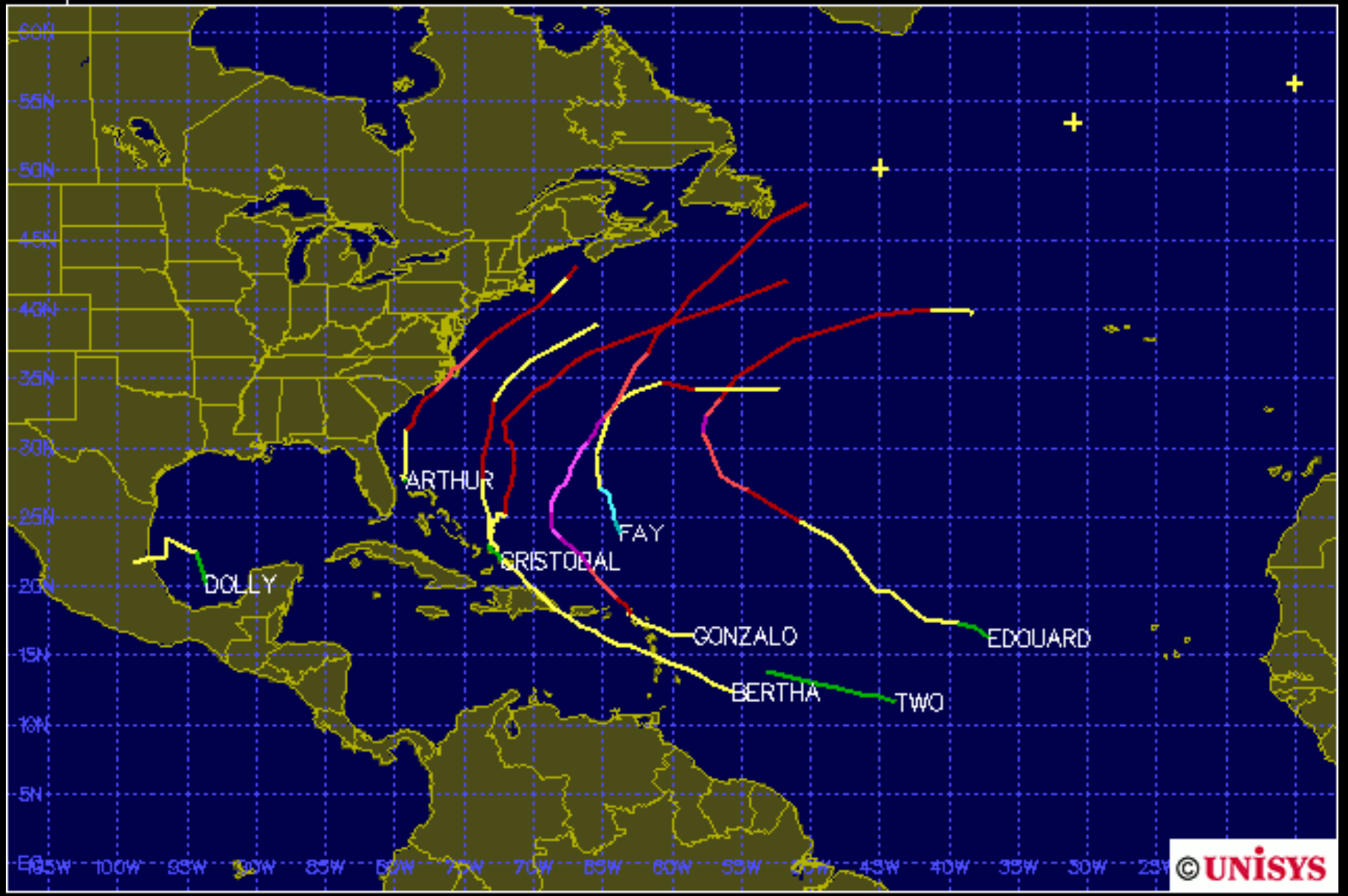

Post-31 July NTC (Observed vs. Cross-Validated Hindcast)
r = 0.88
Observed
Jackknifed Hindcast
250
200
150
100
50
0
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012

2014
Forecast Schedule

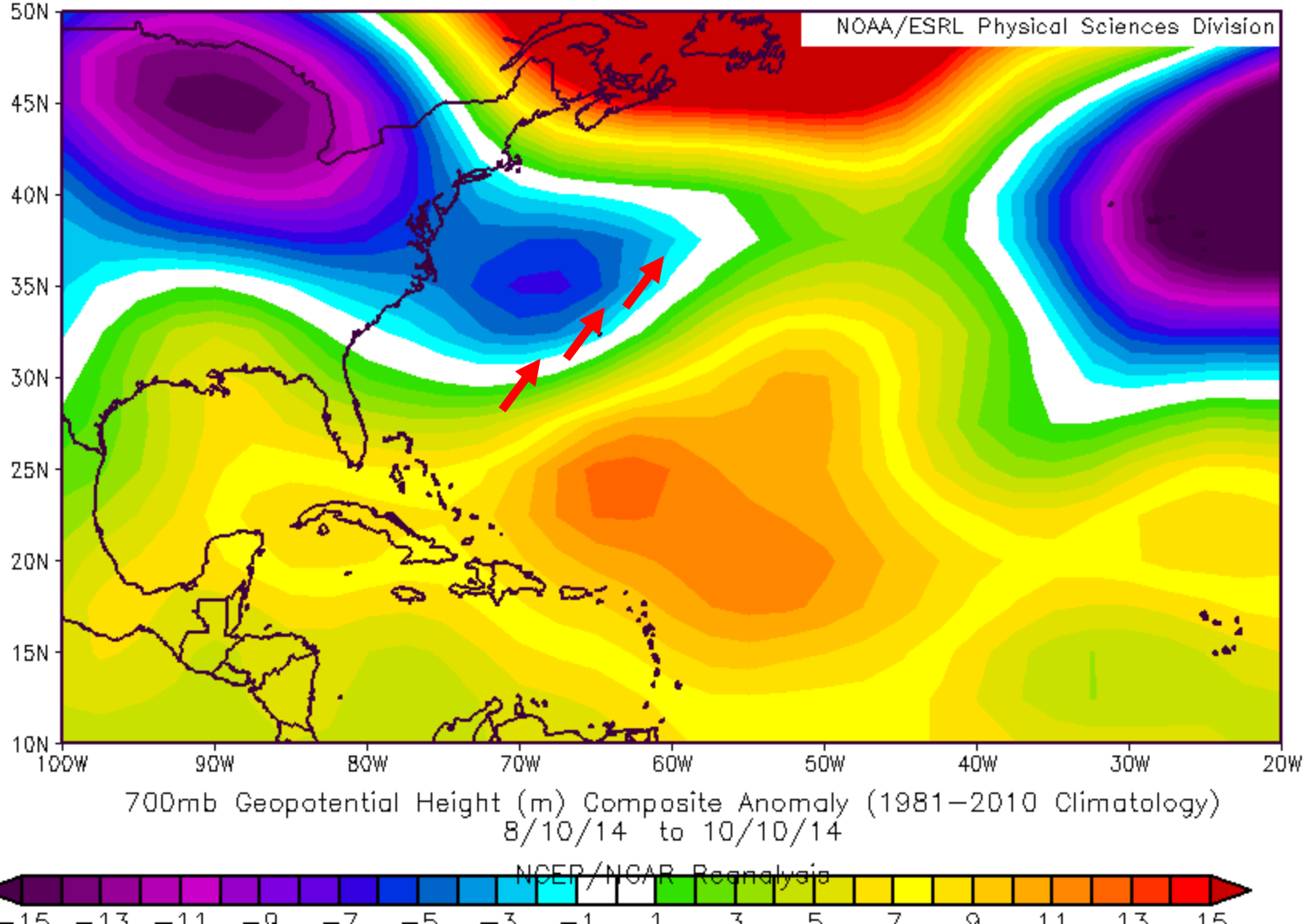
Date	10 April	2 June	1 July	31 July
Seasonal Forecast	X	X	X	X

ATLANTIC BASIN SEASONAL HURRICANE FORECASTS FOR 2014

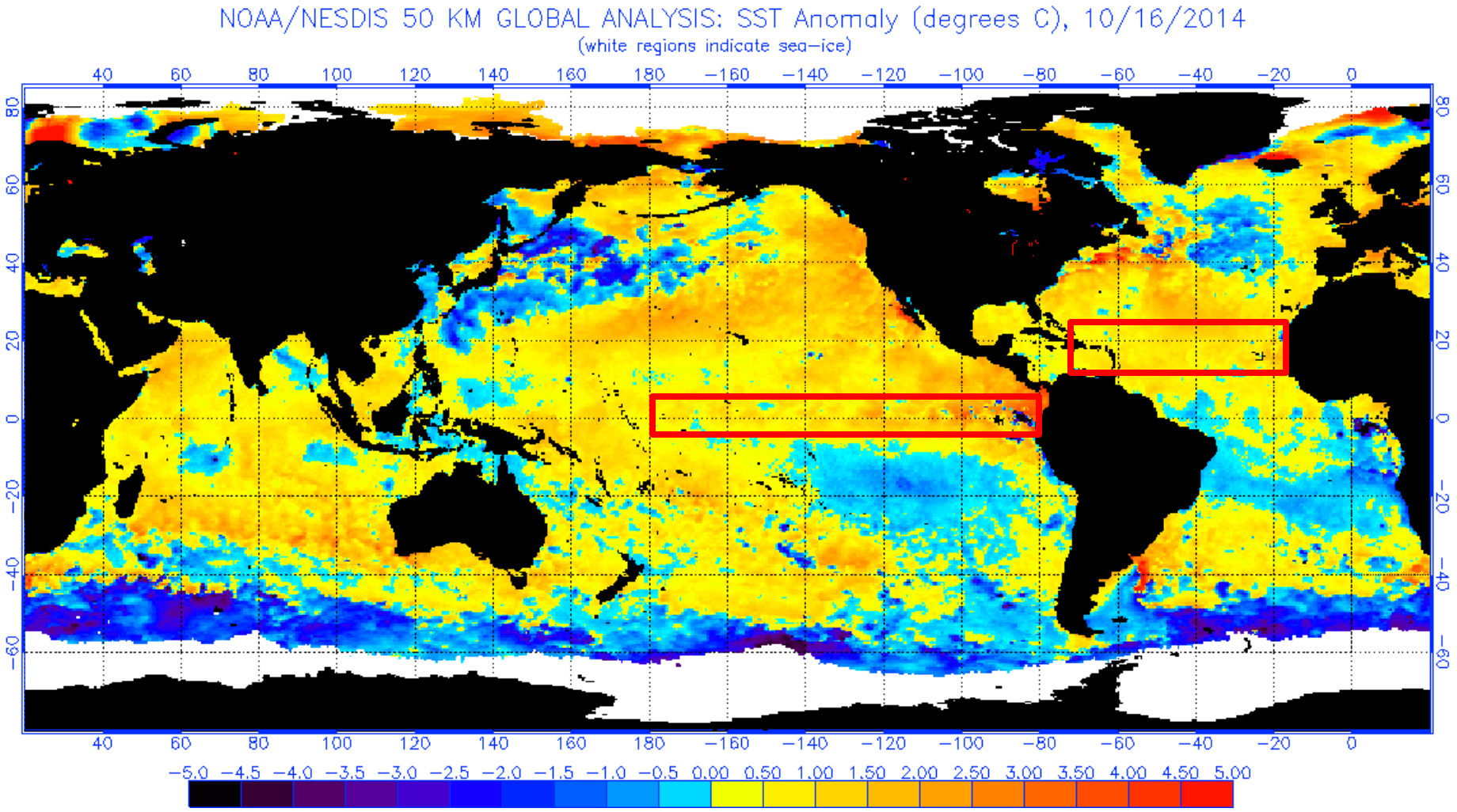
Forecast Parameter and 1981-2010 Median (in parentheses)	10 April 2014	Update 2 June 2014	Update 1 July 2014	Update 31 July 2014	Observed 2014 Total Through Oct. 19	% of 1981-2010 Median
Named Storms (NS) (12.0)	9	10	10	10	7	58%
Named Storm Days (NSD) (60.1)	35	40	40	40	34	56%
Hurricanes (H) (6.5)	3	4	4	4	6	92%
Hurricane Days (HD) (21.3)	12	15	15	15	17	80%
Major Hurricanes (MH) (2.0)	1	1	1	1	2	100%
Major Hurricane Days (MHD) (3.9)	2	3	3	3	3.75	96%
Accumulated Cyclone Energy (ACE) (92)	55	65	65	65	64	70%
Net Tropical Cyclone Activity (NTC) (103%)	60	70	70	70	79	79%


Tropical Storm Tracks
Year 2014
ARTHUR
FAY
CRISTOBAL
DOLLY
GONZALO
EDOUARD
BERTHA
TWO
©UNISYS

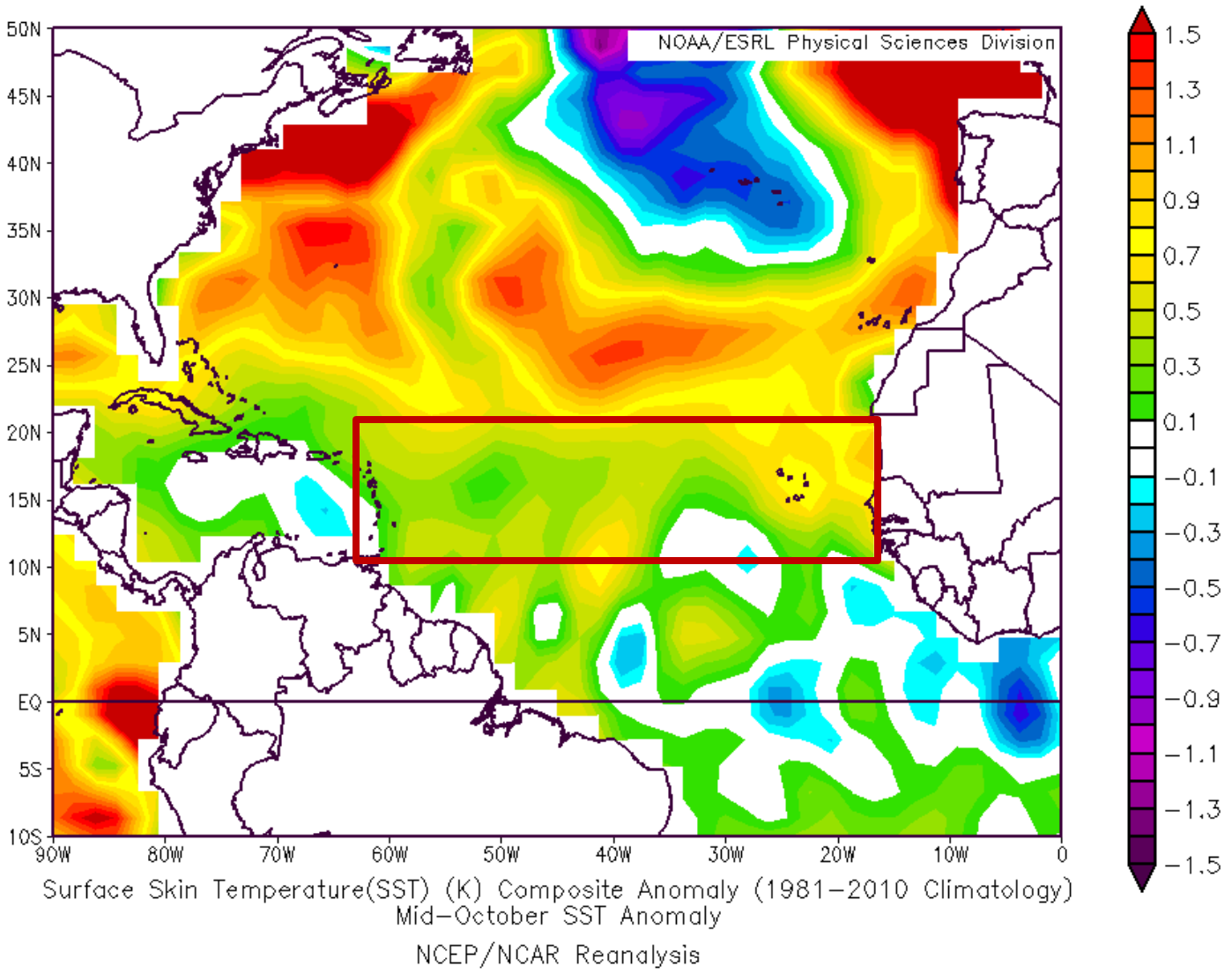
Mid-August – Mid-October 2014 Mid-Level Steering Flow



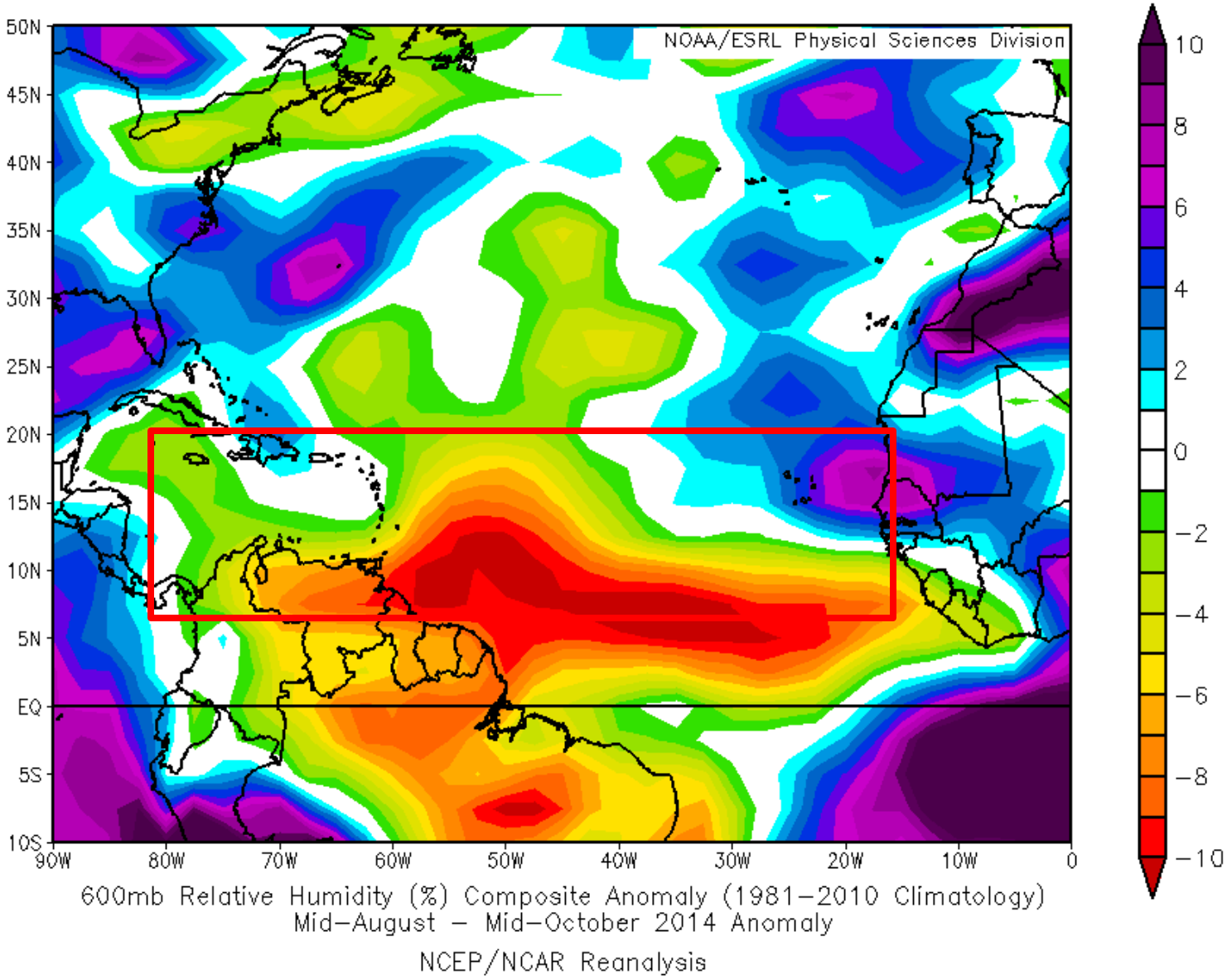
Current Global Sea Surface Temperature Anomaly Map

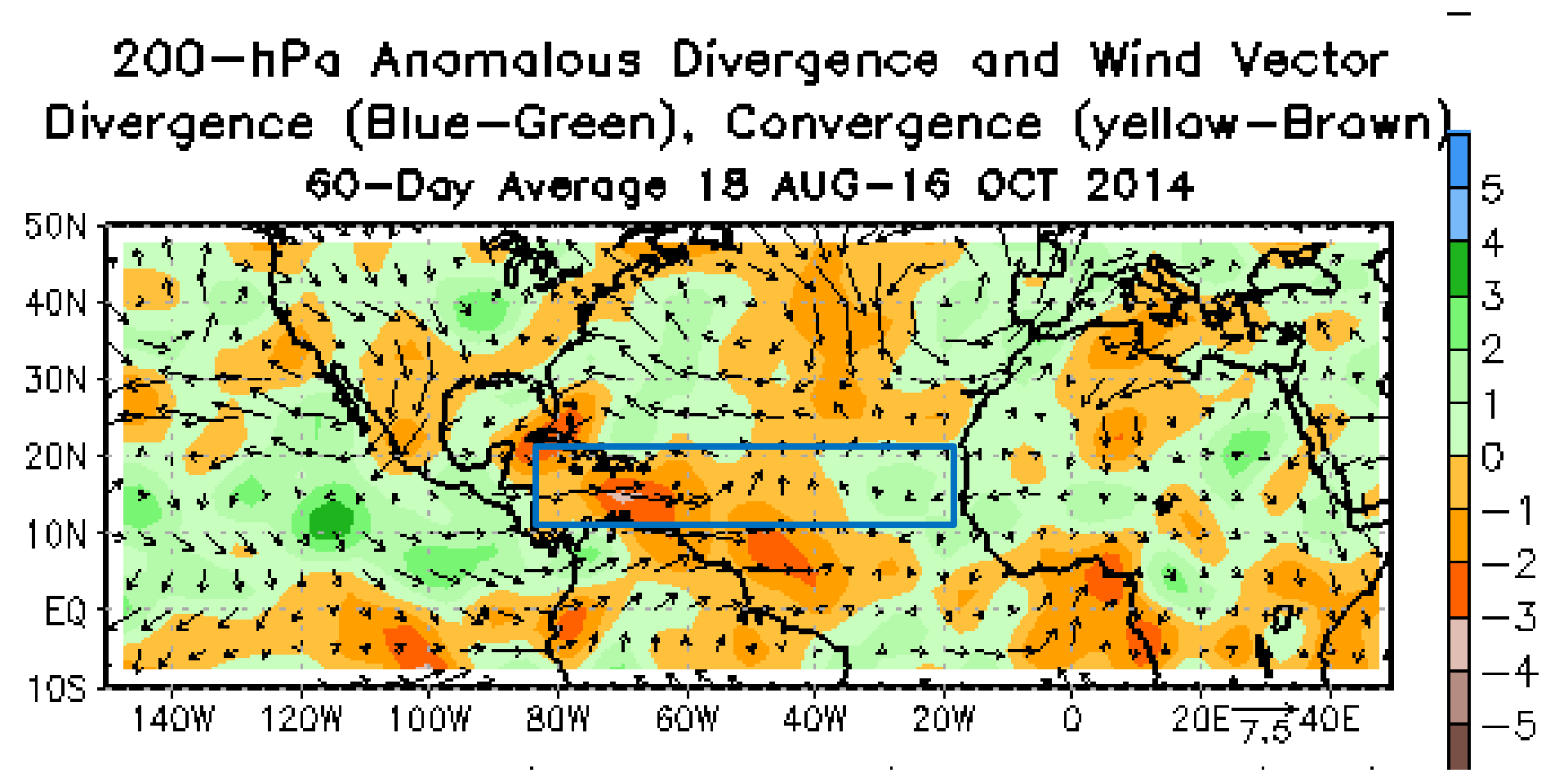


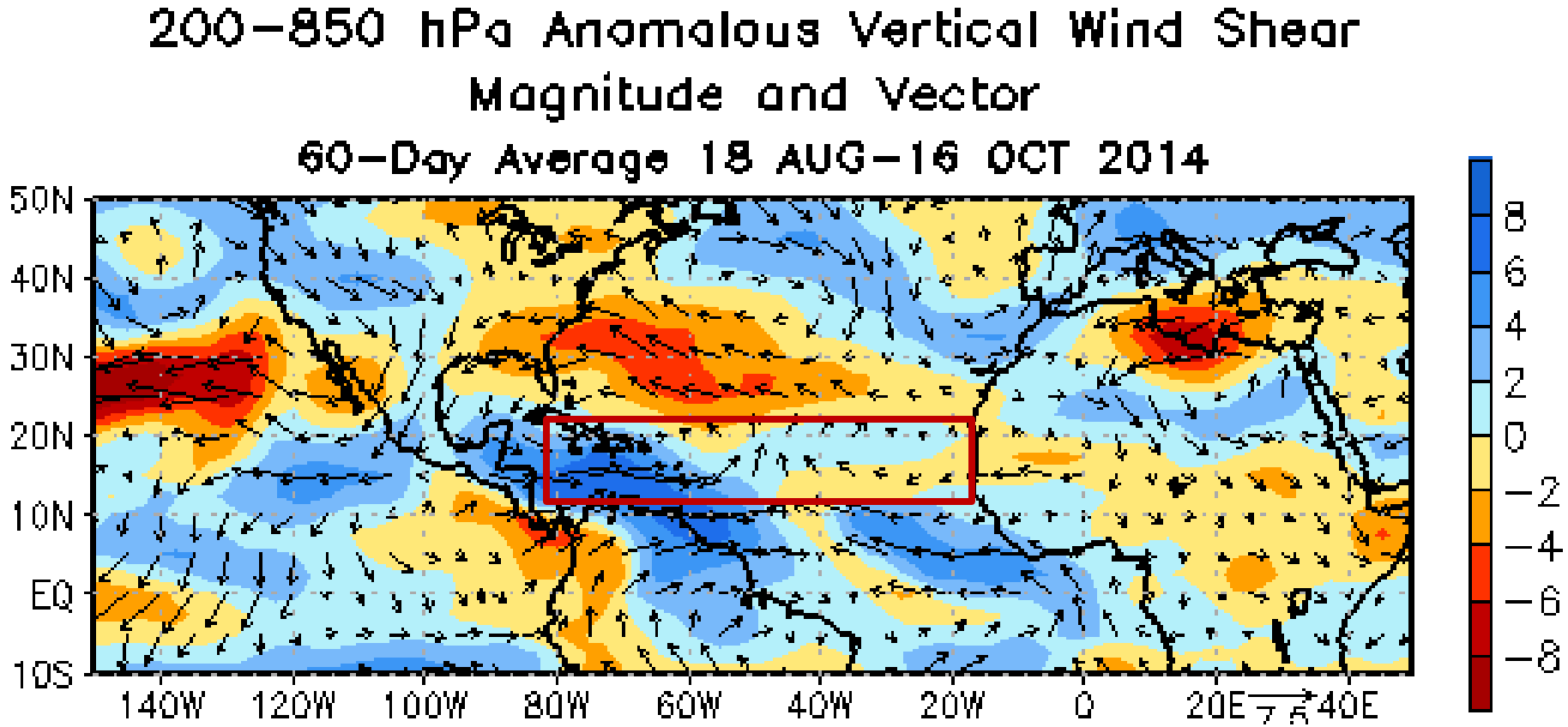
Current Atlantic Basin Sea Surface Temperature Anomaly Map



Relative Humidity Anomalies for the Past 2 Months at ≈14,000 Feet




200-hPa Anomalous Divergence and Wind Vector
Divergence (Blue-Green), Convergence (yellow-Brown)
60-Day Average 18 AUG-16 OCT 2014
50N
40N
30N
20N
10N
EQ
10S
140W
120W
100W
80W
60W
40W
20W
0
20E
40E
7.5
5
4
3
2
1
0
-1
-2
-3
-4
-5


200–850 hPa Anomalous Vertical Wind Shear
Magnitude and Vector
60–Day Average 18 AUG–16 OCT 2014
50N
40N
30N
20N
10N
EQ
10S
140W
120W
100W
80W
60W
40W
20W
0
20E
40E
8
6
4
2
0
−2
−4
−6
−8

Arago's Admonition:

"Never, no matter what may be the progress of science, will honest scientific men who have regard for their reputations venture to predict the weather."