



# 2011 Atlantic Hurricane Activity and Outlooks

## A Climate/ Historical Perspective

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### Related Publications:

- Bell and Chelliah (JCLI 2006, 15 Feb), Chelliah and Bell (JCLI, 2004)
- State of the Climate (BAMS May/June issues 1999-2011)
- [www.cpc.ncep.noaa.gov/products/hurricane](http://www.cpc.ncep.noaa.gov/products/hurricane): Seasonal summaries/ outlooks



# 2011 Atlantic Named Storms to Date

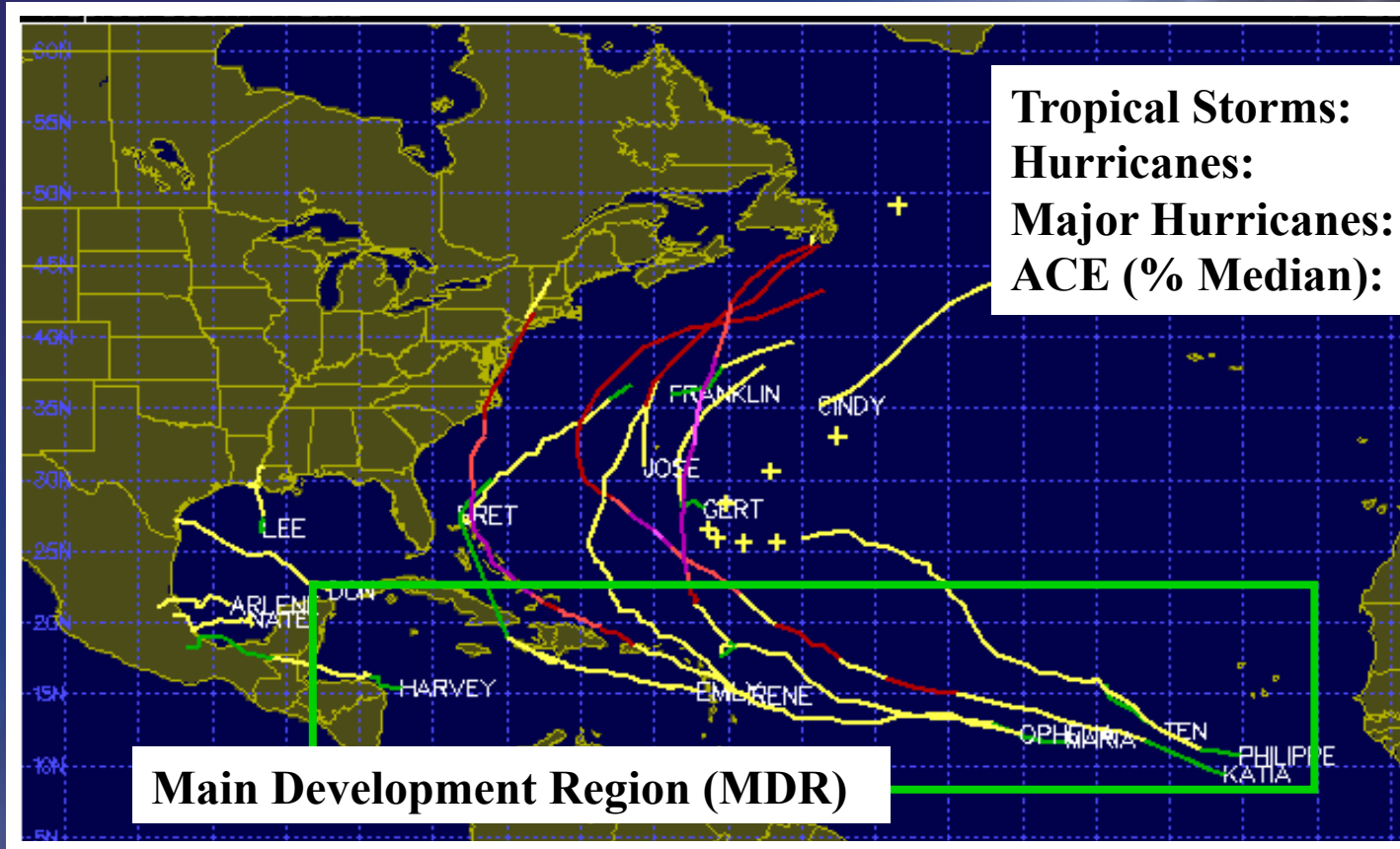






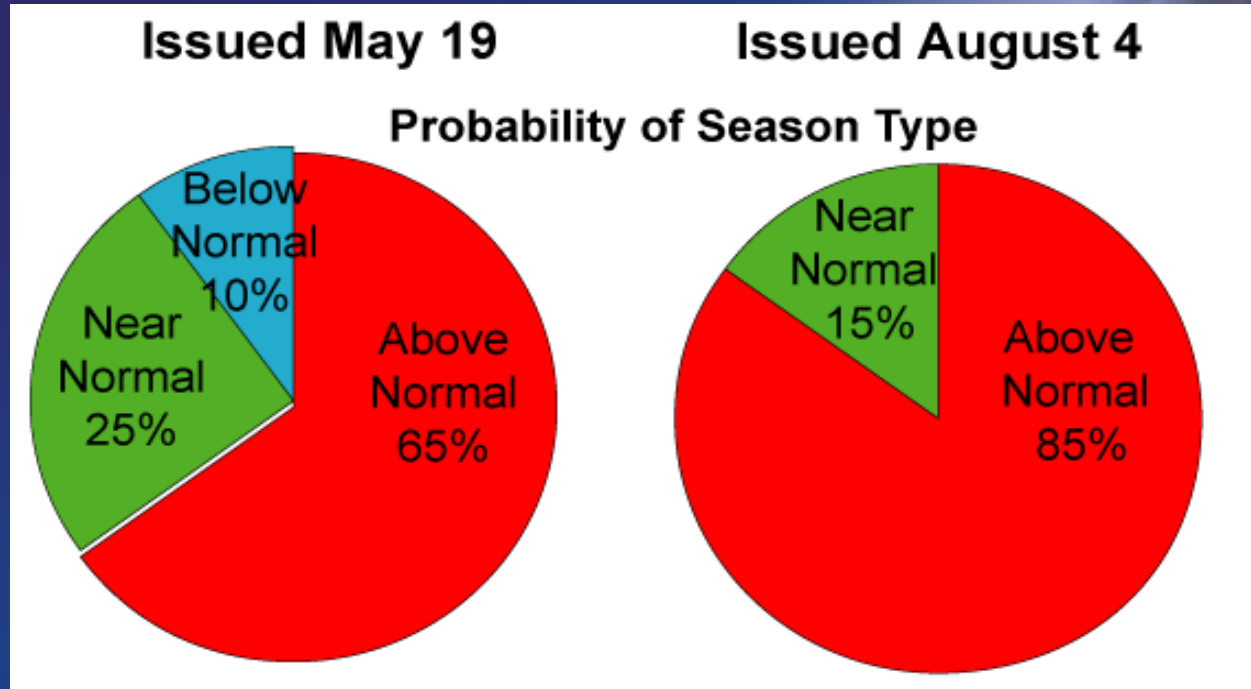
Figure Courtesy: [Weather.Unisys.com](http://Weather.Unisys.com)

**Much activity (9 NS, 4 H, 3 MH, 92% total ACE) linked to named storms originating in MDR.**

Legend	
	<b>Tropical Depression</b>
	<b>Tropical Storm</b>
	<b>Hurricane</b>
	<b>Major Hurricane</b>



# NOAA's 2011 Atlantic Hurricane Season Outlooks



Official CPC product made in collaboration with NHC/NWS and HRD/NOAA

Expected Ranges of Activity <i>70% Probability For Each Range</i>			
<b>Named Storms</b>	<b>12-18</b>	<b>Named Storms</b>	<b>14-19</b>
<b>Hurricanes</b>	<b>6-10</b>	<b>Hurricanes</b>	<b>7-10</b>
<b>Major Hurricanes</b>	<b>3-6</b>	<b>Major Hurricanes</b>	<b>3-5</b>
<b>ACE (% median)</b>	<b>105-200</b>	<b>ACE (% median)</b>	<b>135-210</b>

Observed
<b>16</b>
<b>4</b>
<b>3</b>
<b>109%</b>



# Model Summary For Outlook Issued August 4th

Statistical

Model	Named Storms	Hurricanes	Major Hurricanes	ACE (% of median)
Regression	14-18	7-10	3-5	145-185
Climate Analogue	14-19	7-11	3-5	157-245

Statistical-Dynamical Hybrid

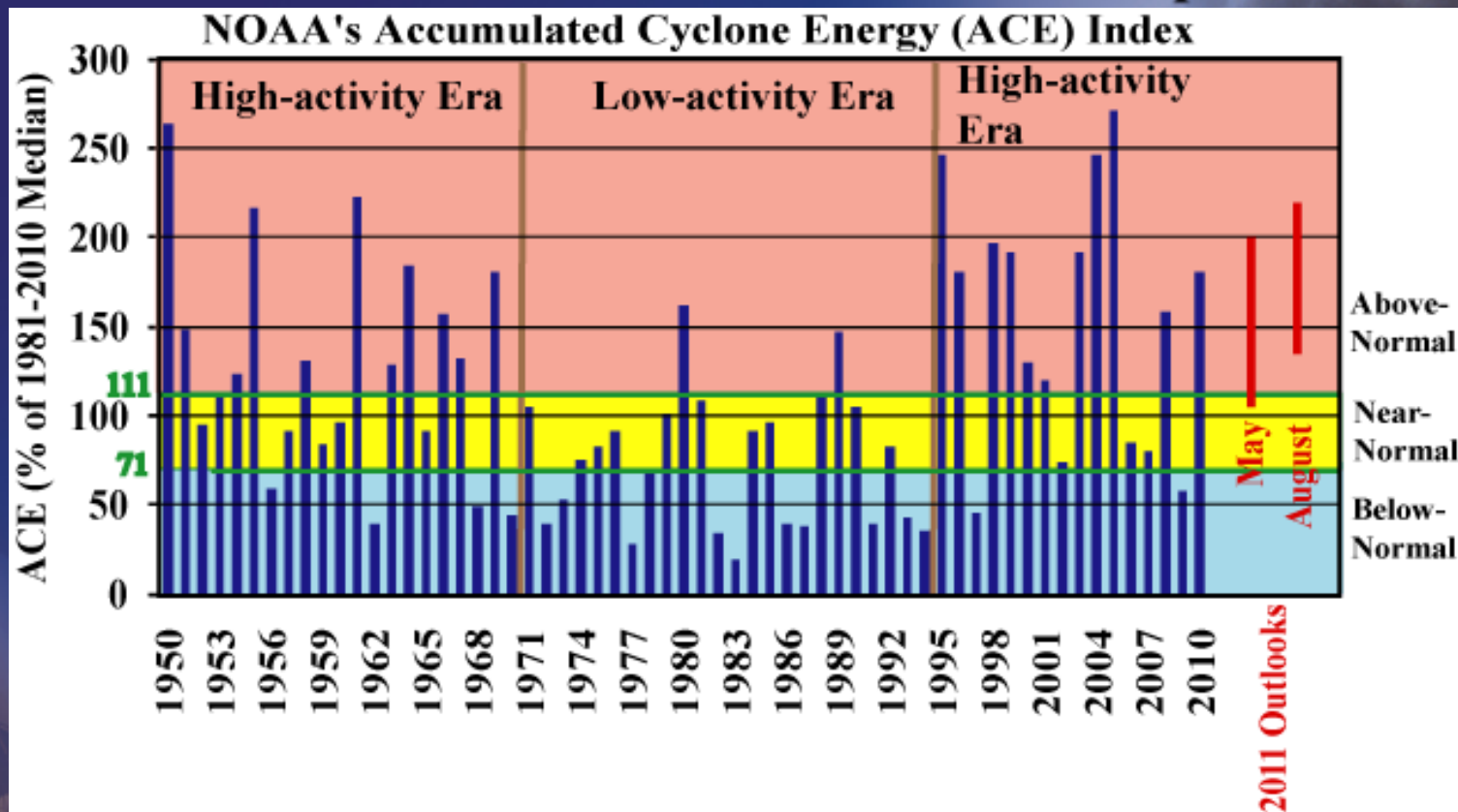
<b>CFS: Lo-Res (T62)</b>	16-18	9-11	4-5	165-224
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Dynamical

<b>CFS: Hi-Res (T382)</b>	15-25	5-8	-	89-161
<b>GFDL</b>	15	11	-	-
<b>ECMWF</b>	14-19	3-8	-	106-258
<b>EUROSIP</b>	18-25	-	-	74-143
<b>UKMET</b>	11-18	-	-	77-186



# 2011 ACE Outlook In A Historical Perspective



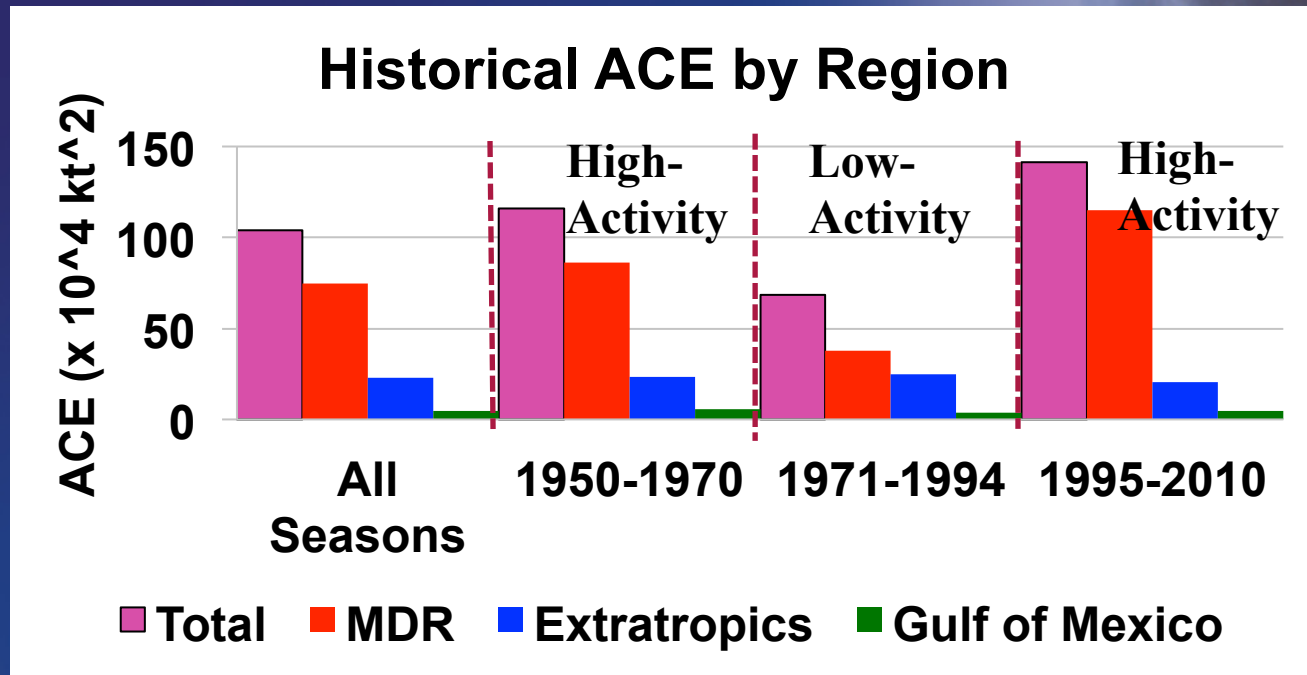
$$ACE = \sum_{NS} \sum_{T} V_{max}^2 \quad \text{for all named storms while at least TS strength (4x daily).}$$

- Step-Function characterizes transitions between high-and low activity eras. (No trends during individual eras).
- 2011 Outlooks reflect expected continuation of high activity era.



# Examine Multi-Decadal Fluctuations in ACE

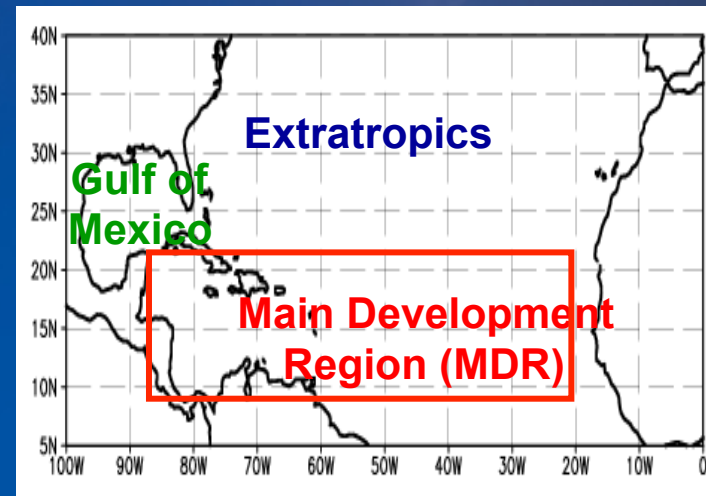
## Subdivide Atlantic Basin into Three TS Formation Regions

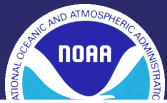


Named storms that form in MDR (Red):

1. Produce 75+ % of ACE during high activity eras.
2. Explain entire multi-decadal variability in ACE, hurricanes, and major hurricanes.

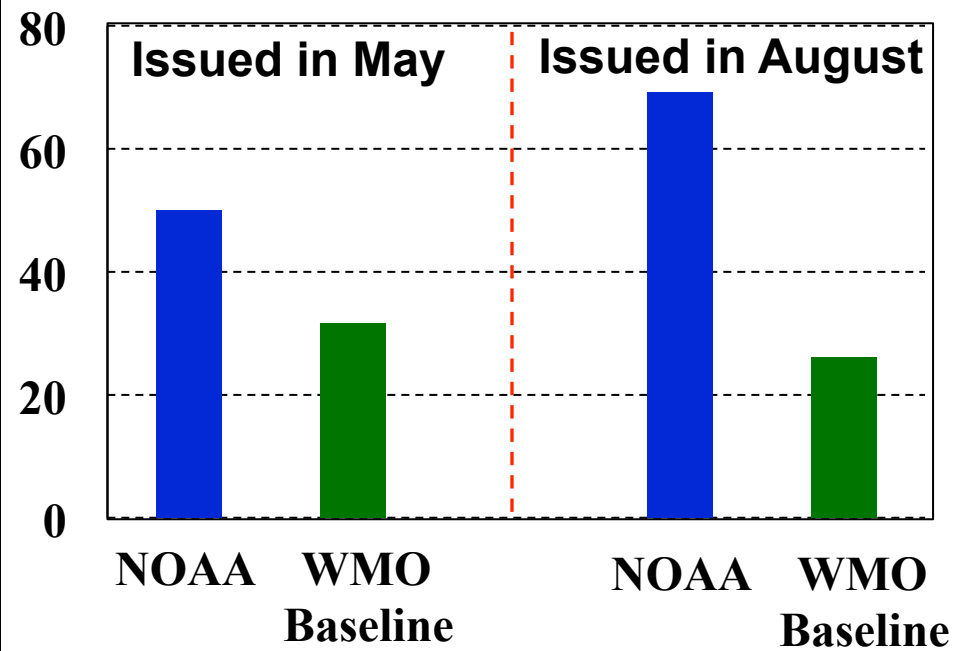
**Strong climate predictors exist because they directly influence conditions/ activity within the MDR.**



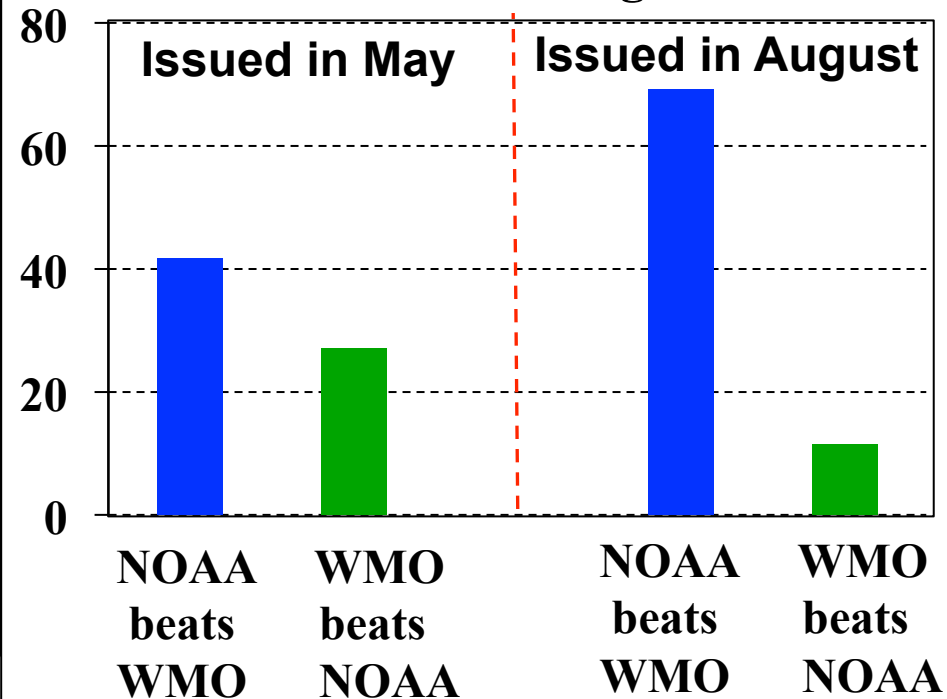


# NOAA Atlantic Seasonal Hurricane Outlook Verification

### Percent Correct Outlooks



### Conditional Rank Probability Score % Seasons with Higher Score



WMO baseline forecast = Preceding 5-yr avg.  $\pm 1\sigma$  calculated from preceding 30-yr

- NOAA's outlooks have much higher skill than WMO baseline (no-skill) forecast.
- Conditional Rank Probability Score addresses forecast accuracy and spread.



## Expected Conditions During Aug.-Oct. 2011

Warmer SSTs  
Reduced Wind Shear  
Lower Surface Pressure  
*(red area)*

Higher Pressure in  
Upper Atmosphere

Favorable African Easterly Jet

Upper-level  
Easterlies Expand  
Westward  
*(Green arrows)*

Weaker Easterly  
Trade Winds  
*(dark blue arrow)*

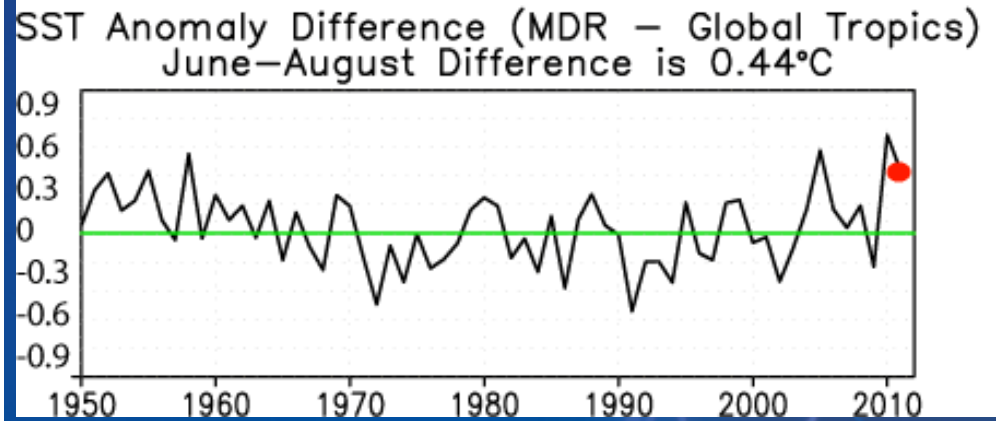
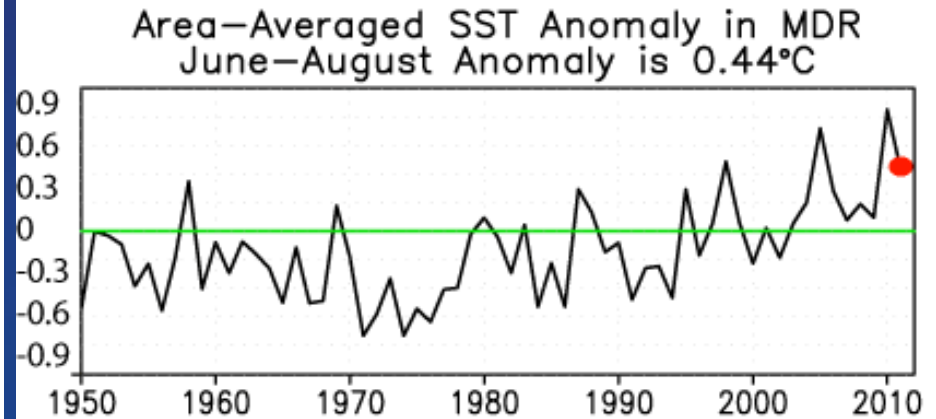
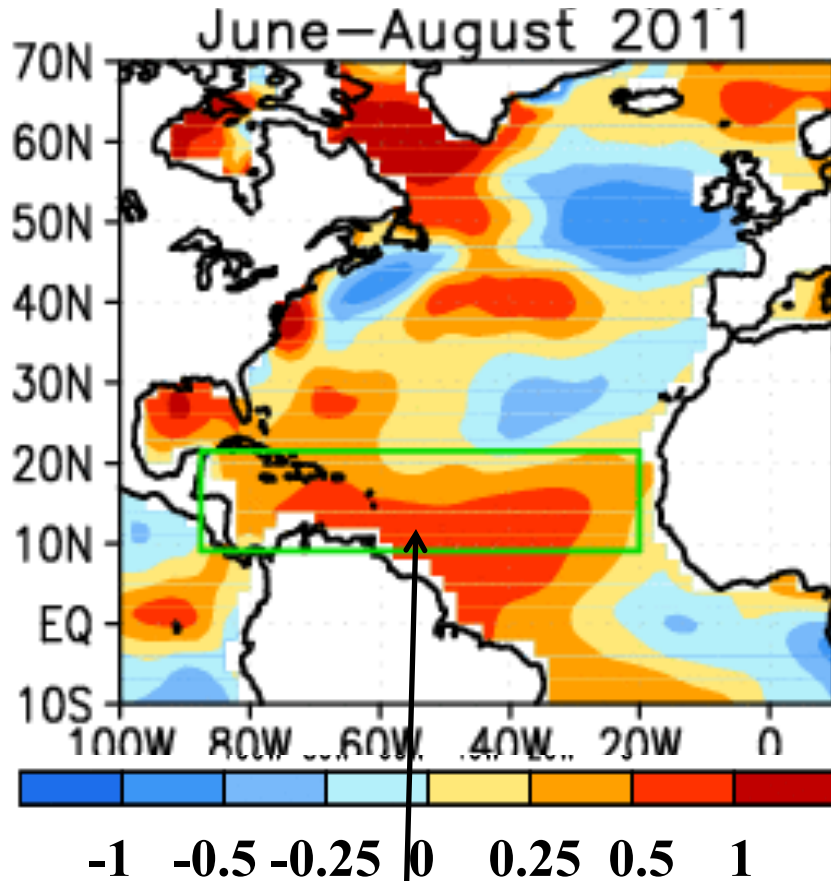
- This inter-related set of conditions typifies active seasons during a high activity era, and produces increased activity in MDR.
- August 2011 outlook based on prediction of three climate factors: ongoing active Atlantic phase of tropical multi-decadal signal, possible La Niña, and exceptionally warm Atlantic SSTs.





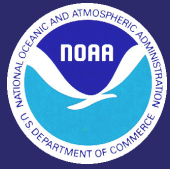
# SST Anomaly ( $^{\circ}\text{C}$ ): June-August 2011

ERSST V.3b Data

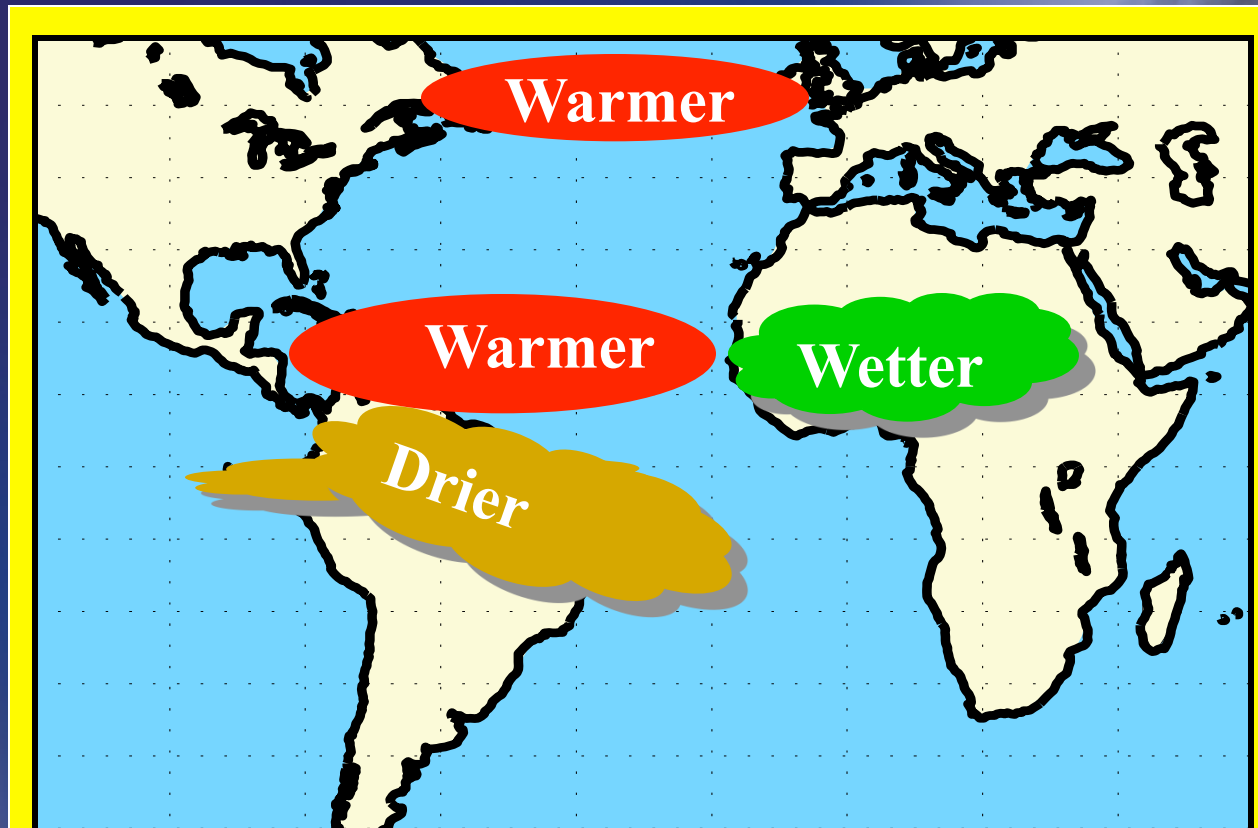


**Exceptionally warm SSTs in MDR, much warmer than global Tropics.**

**Main Development Region (MDR)**



# Aug-Oct Tropical Multi-Decadal Signal Phase shown for Active Atlantic Hurricane Era



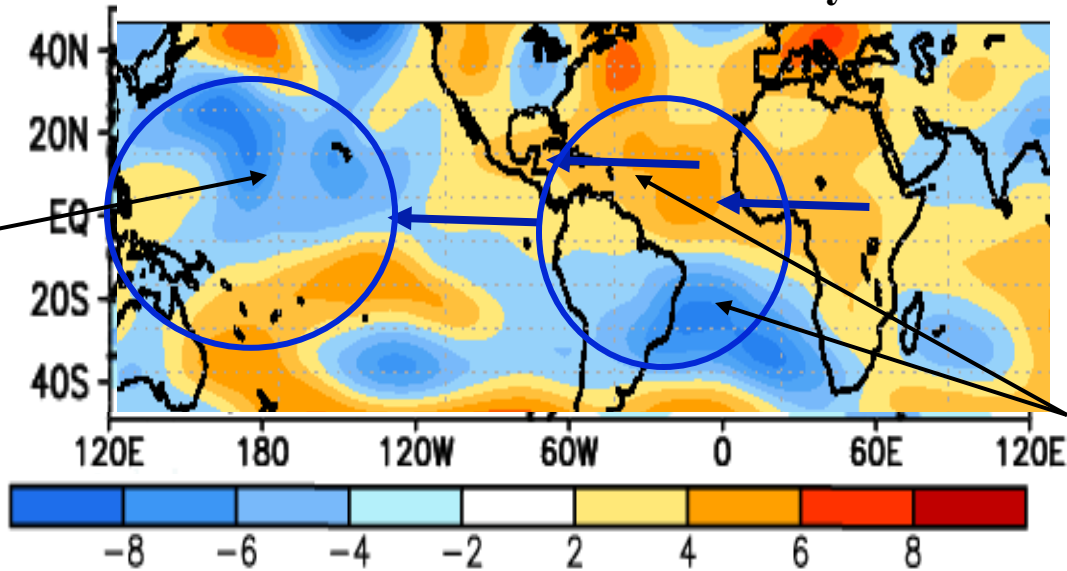
• EOF analysis applied to 5-yr running ASO 200-hPa velocity potential anomalies (From Bell and Chelliah, JCLI 2006).

• This climate pattern accounts for many inter-related regional atmospheric anomalies known to favor increased MDR activity.



# 200-hPa Streamfunction Anomalies

Observed: Most Recent 60 days

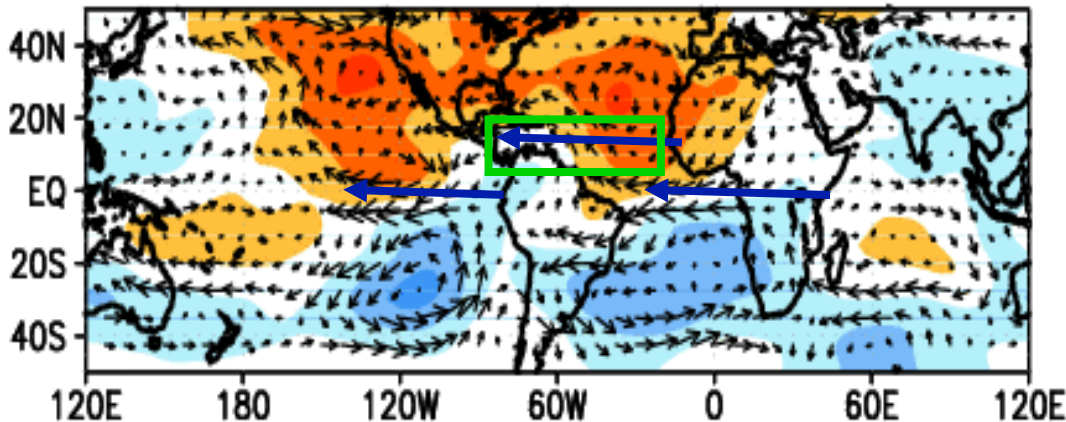


La Niña

Tropical multi-decadal signal

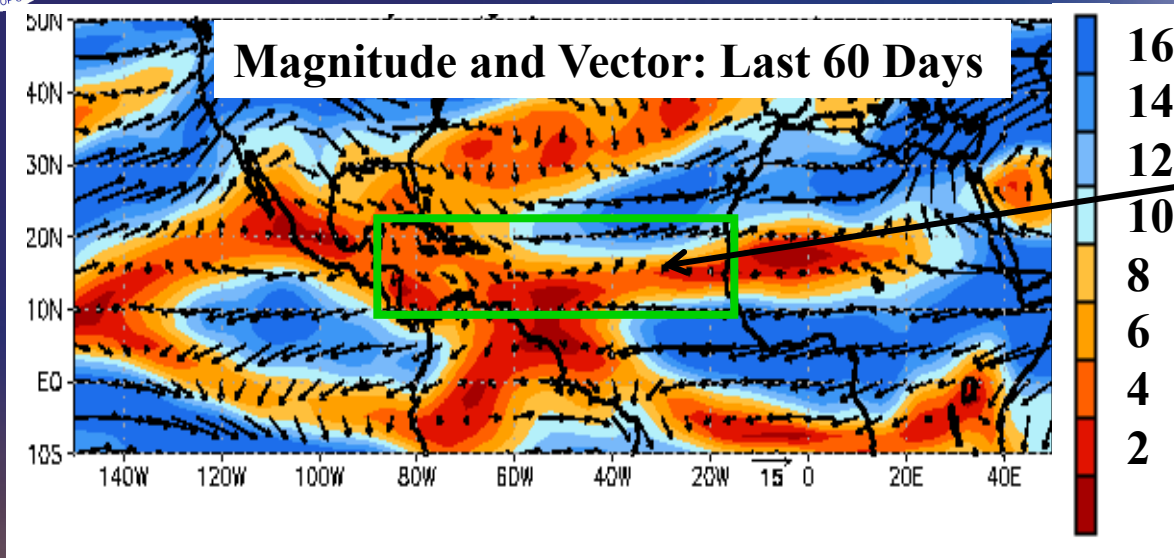
Stronger upper-level ridges in both hemispheres, easterly wind anomalies across tropical Atlantic.

ASO: 1995-2010 minus 1971-1994

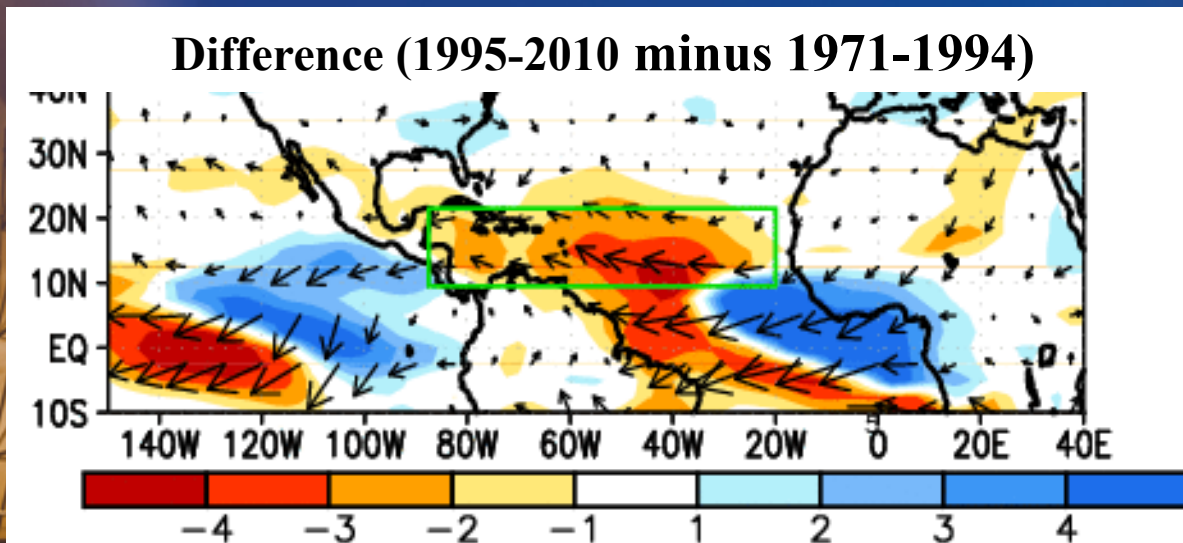




# 200-850 hPa Vertical Wind Shear (m/s)



Axis of weak shear (Red) across MDR typifies active season and high activity era.

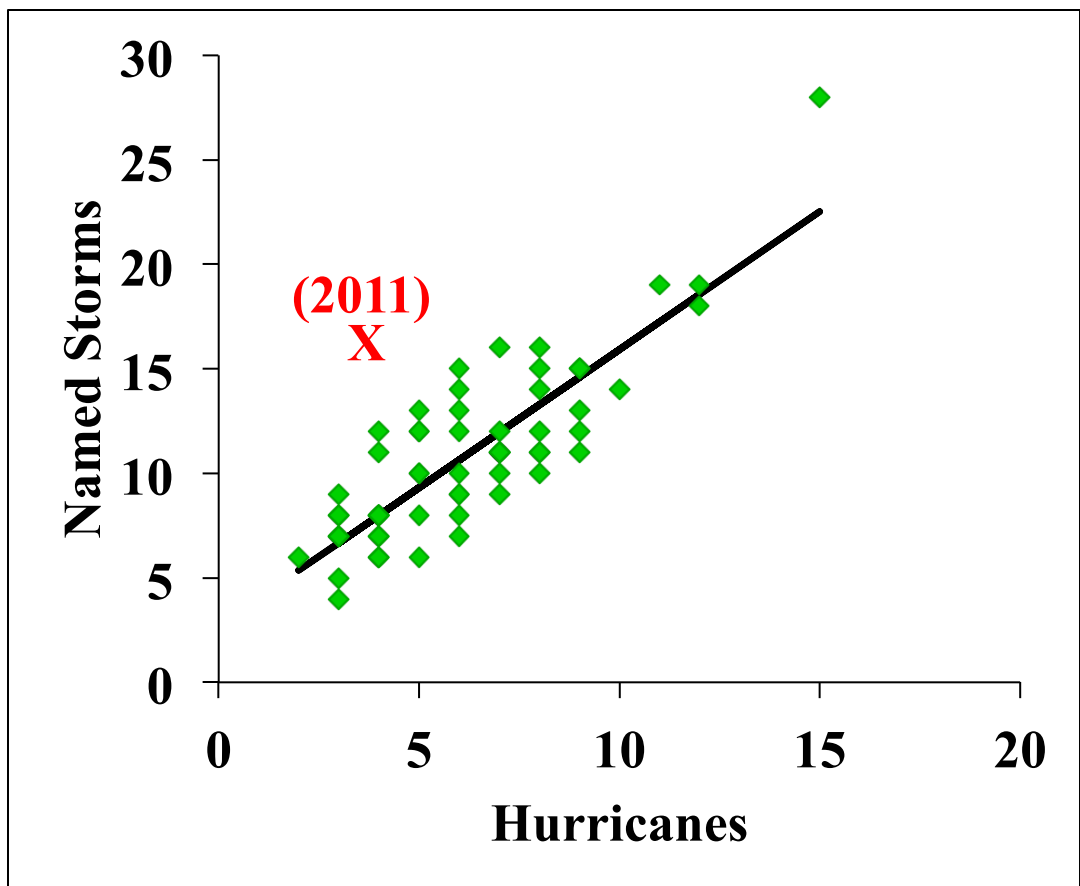


3-celled pattern shows large-scale differences in vertical wind shear between high- and low-activity era.



# BUT... We've Only Had 4 Hurricanes!!!

## Historical Scatter Plot: Seasonal Named Storms vs Hurricanes

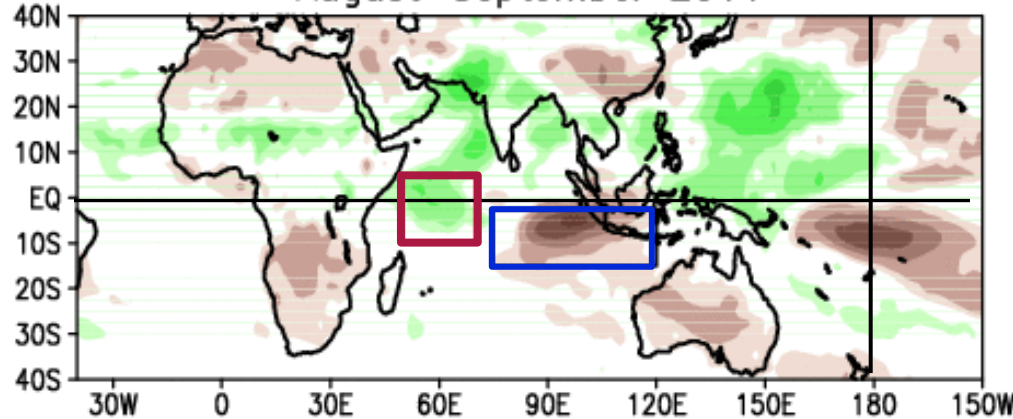


**Normally expect 7-9 hurricanes for 16 named storms, with 6-7 forming from named storms that originated in MDR.**

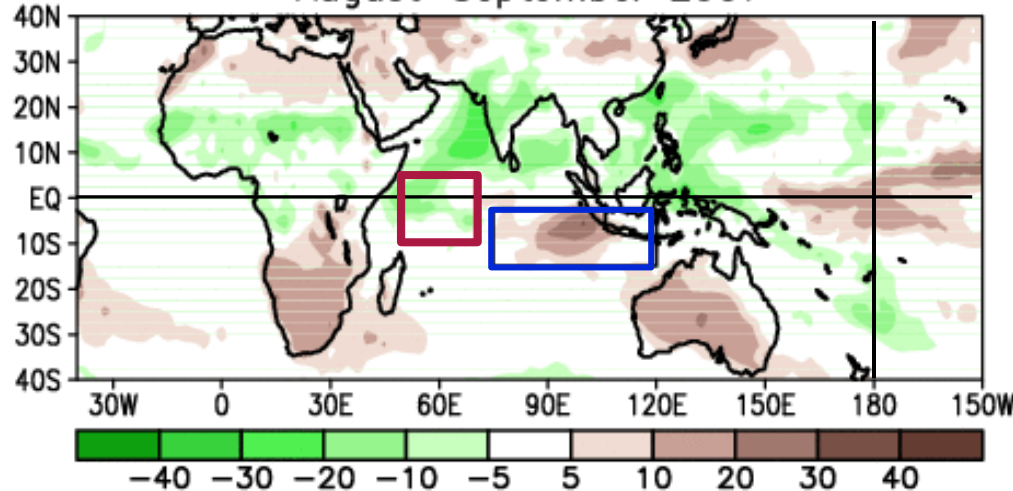


# Why Only 4 Hurricanes? Reason #1 Seen in OLR Anomalies ( $W m^{-2}$ )

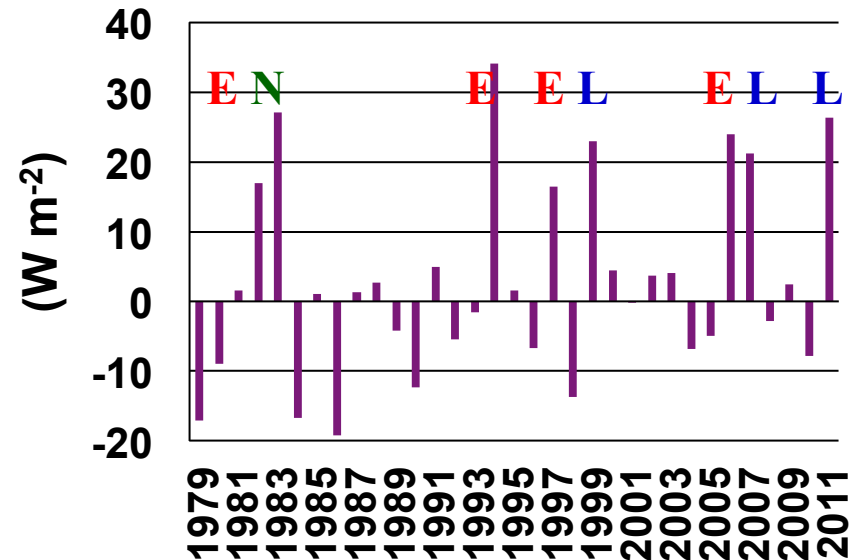
August–September 2011



August–September 2007



Indian Ocean Dipole (IOD) Index  
(Eastern IO minus Western IO)



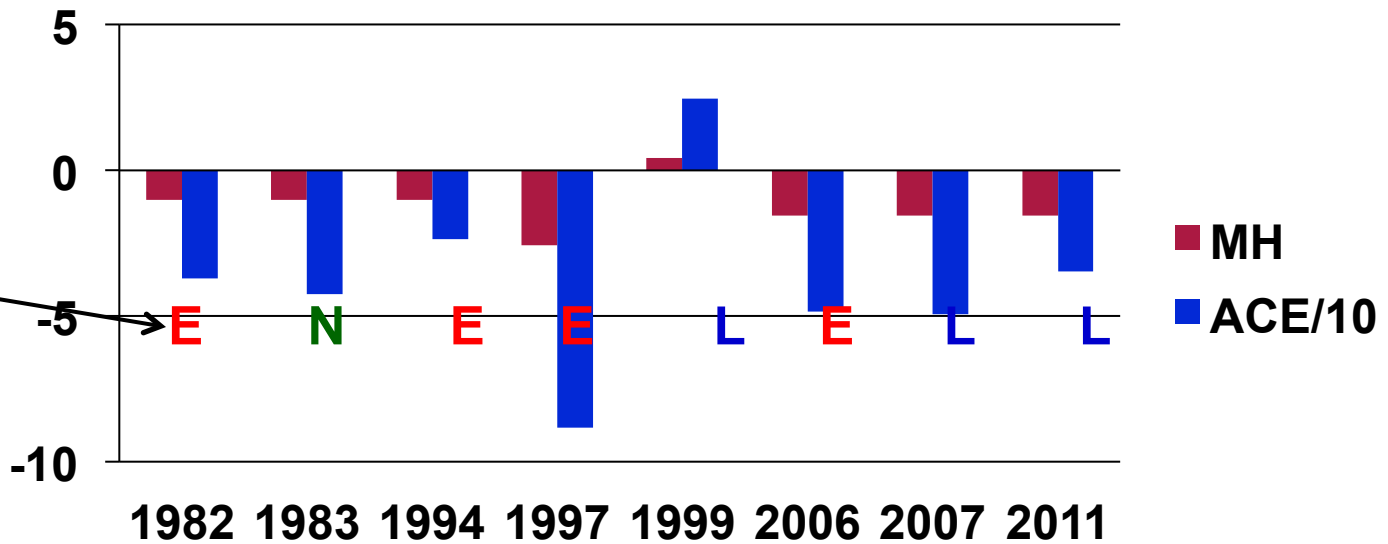
- Strong positive IOD index in 2011
- IOD does not increase explained variance of ACE over tropical multi-decadal signal+ENSO+Atlantic SSTA.

2011 OLR pattern similar to 2007  
over Indonesia and western Indian Ocean.



# Positive Indian Ocean Dipole (IOD) Index and Hurricane Activity in MDR.

## Anomalous MDR Activity Strong Positive IOD



ENSO Phase

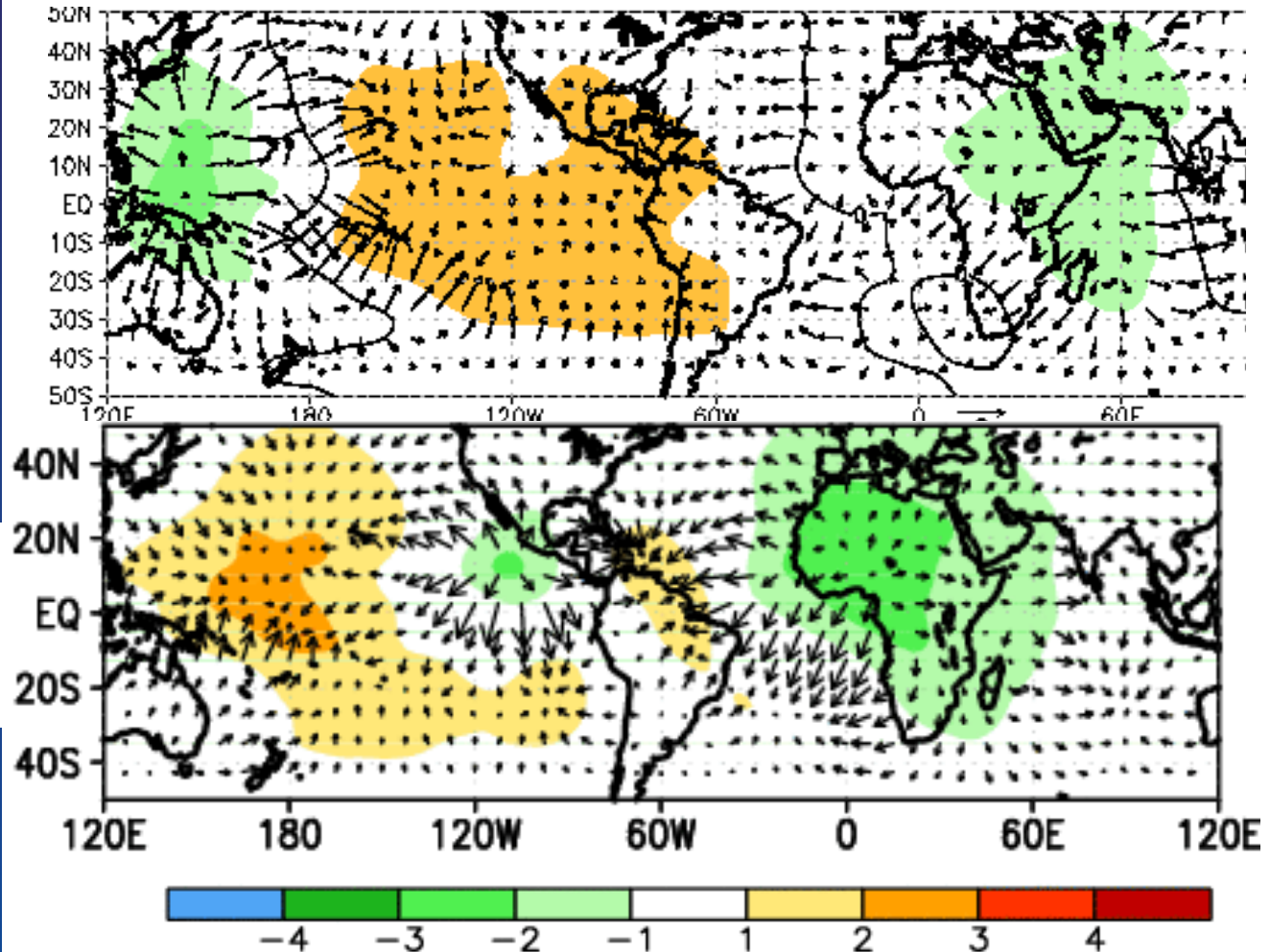


**Strong positive IOD index often associated with suppressed MDR activity.**



# 200-hPa Anomaly Velocity Potential and Divergent Wind Vector

Last 60-days

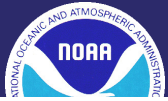


Aug-Oct:  
1995-2010 minus  
1971-1994

Positive IOD in 2011 shifted center of divergent circulation to eastern Africa/ western Indian Ocean.

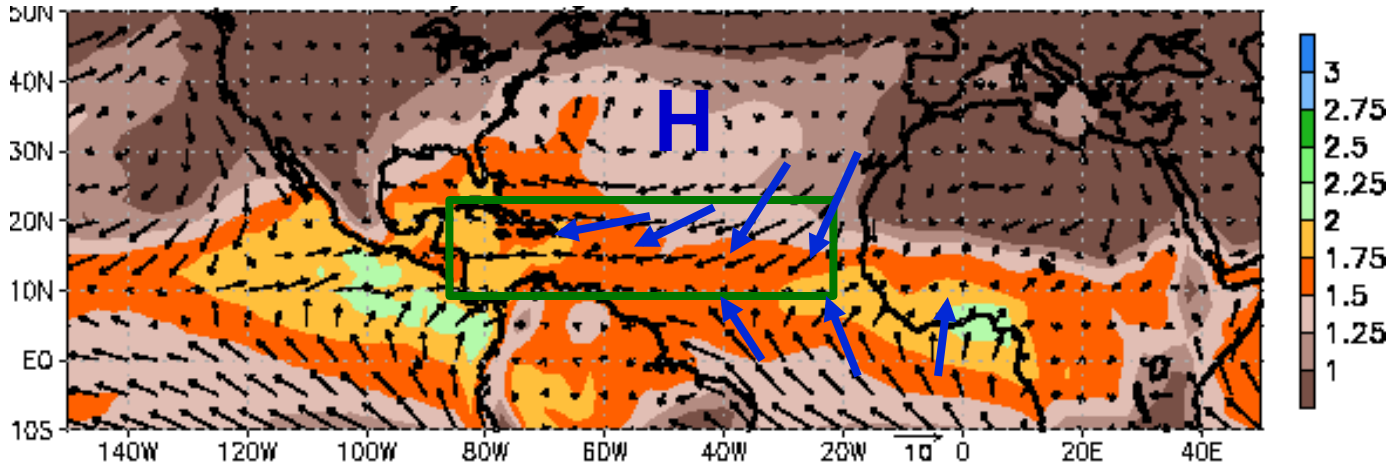






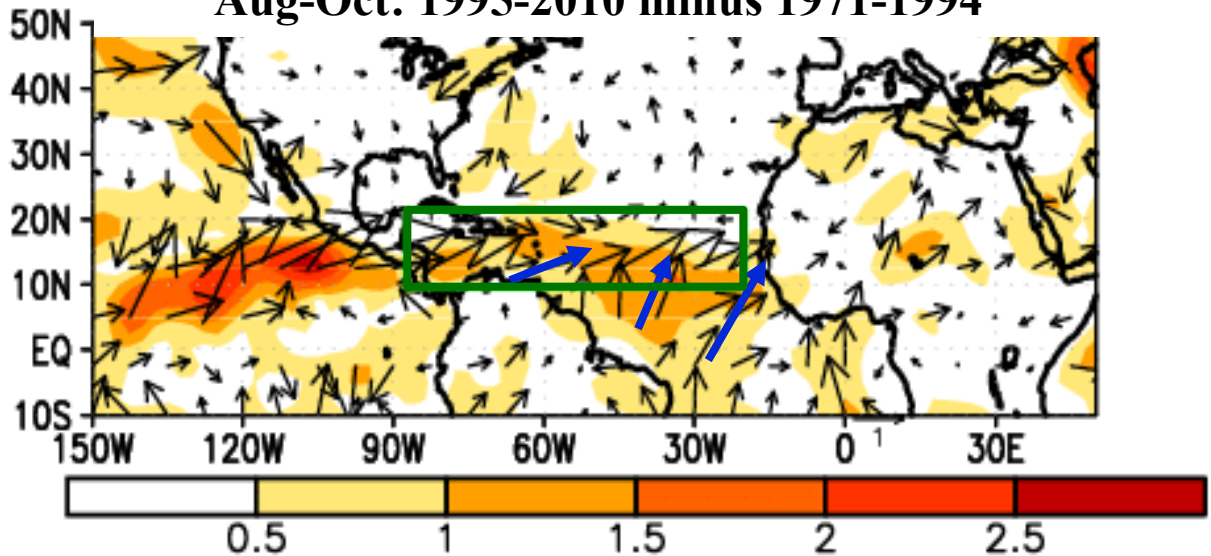
# Why Only 4 Hurricanes? Reason #2.

## Precipitable Water (Inches), 1000-hPa Wind Vector (Last 30 Days)



**Amplified High pressure and dry, northeasterly flow dominates central/eastern MDR.**

## 1000-hPa Wind Speed and Vector Aug-Oct: 1995-2010 minus 1971-1994



**High activity era has featured extensive southerly flow of moist tropical air into MDR.**



# Summary

**Skill from seasonal outlooks comes from predicting climate factors that affect conditions in the MDR—Dynamical models critical for ENSO, SST forecasts.**

**Inter-related set of atmospheric and oceanic conditions during 2011 are consistent Atlantic high activity era and very warm Atlantic SSTs.**

**To date, fewer hurricanes than expected: I have speculated on two causes.**

- 1. Strong positive phase of Indian Ocean Dipole- A climate factor- Affects west African monsoon circulation, reduced southerly transport of deep tropical moisture into southern MDR.**
- 2. Strong high-pressure over central Atlantic- a weather/ synoptic factor- Higher pressure results in dry subsiding air in MDR, unfavorable for hurricane formation**