2004 Hurricane Season: Climate Overview and Lessons Learned

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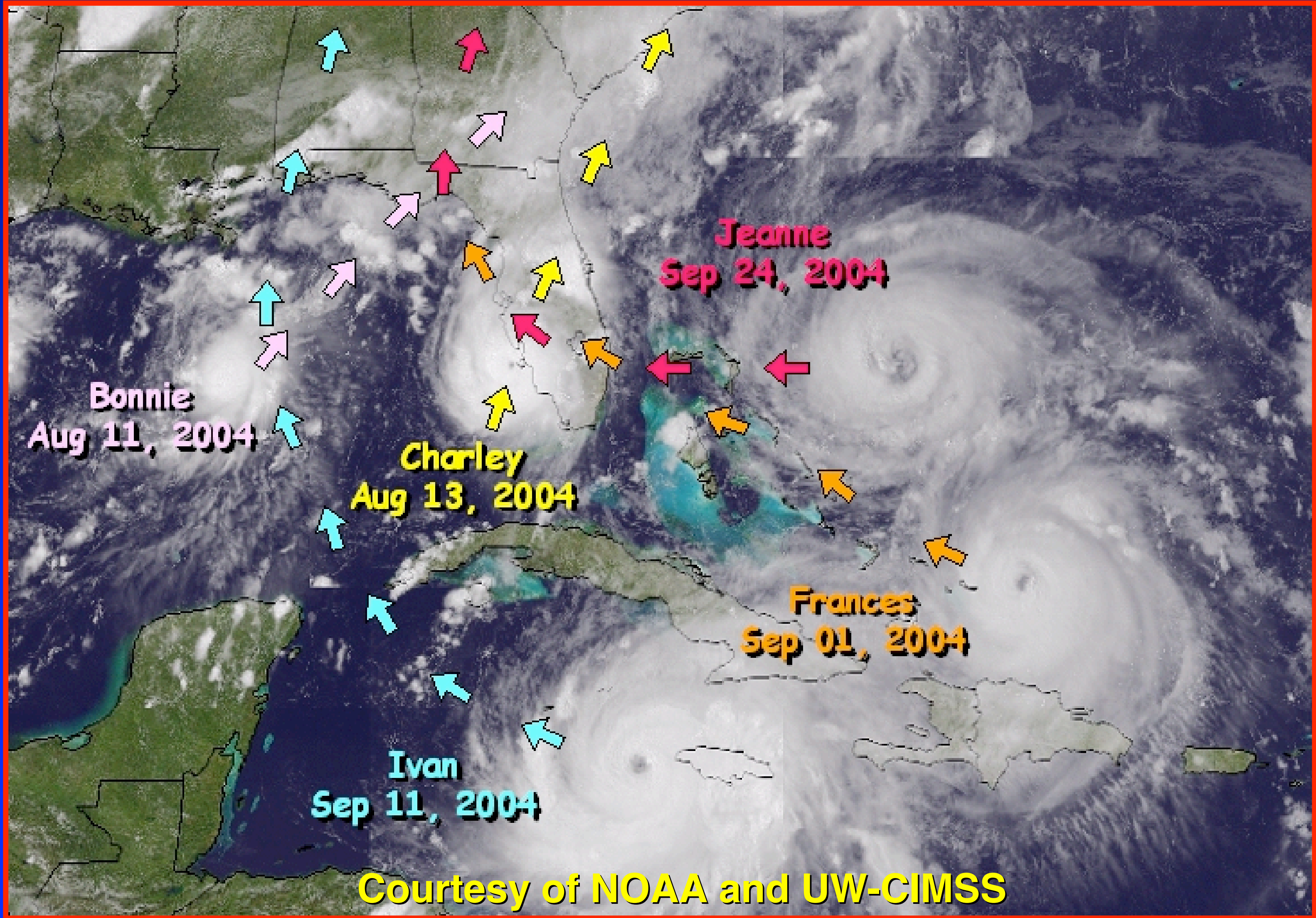
Florida Damaging Storms 2004



Structure

1. Climate overview of 2004 Atlantic hurricane season.
2. How well was 2004 hurricane activity predicted?
3. Anomaly or trend?
4. Lessons learned and future risks for Florida.

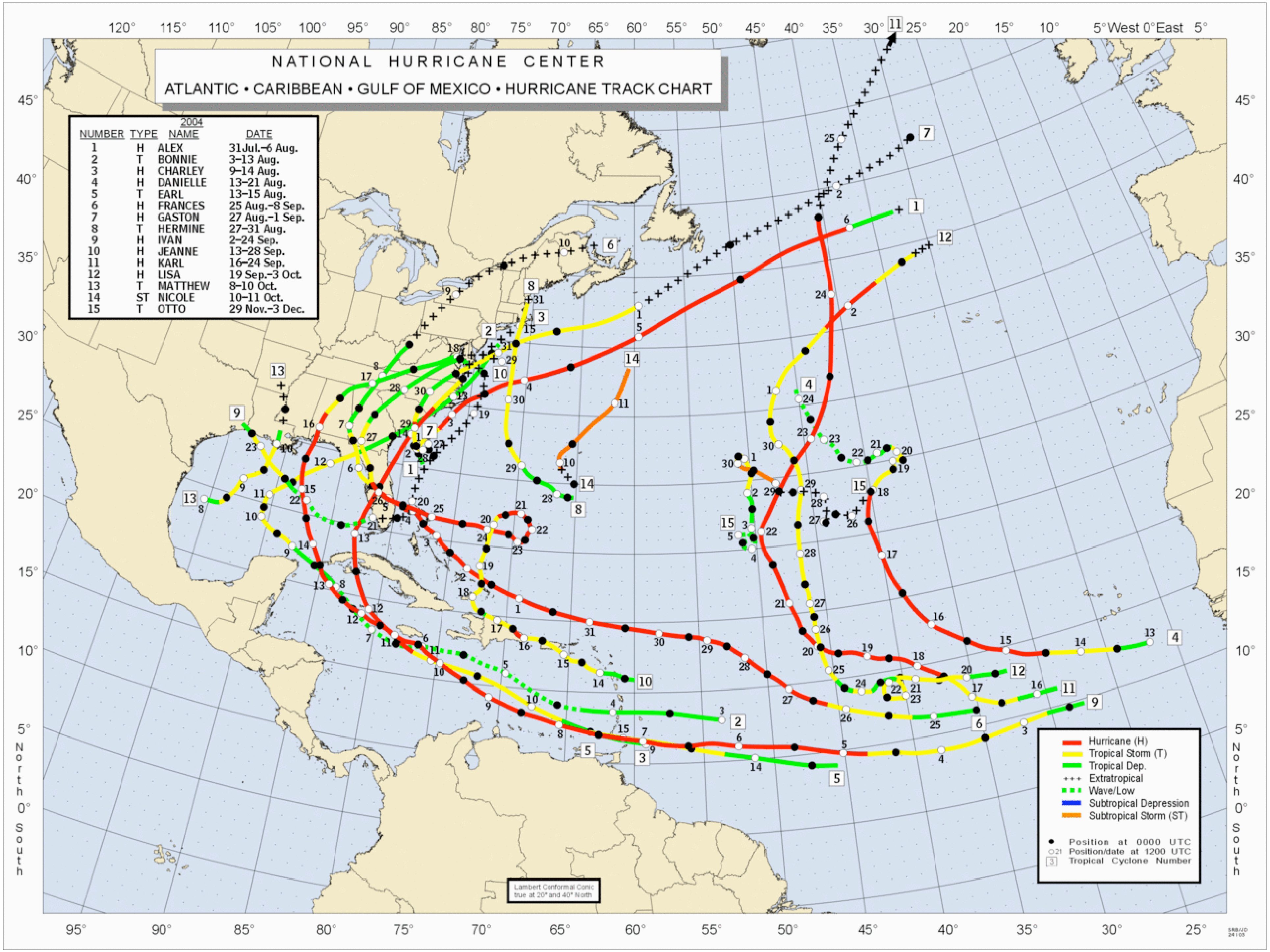
1. Climate Overview of 2004 Hurricane Season

a) Observed activity and losses

b) Unusual features of 2004

c) Where does 2004 rank?

d) Why was 2004 so active?


NATIONAL HURRICANE CENTER
ATLANTIC • CARIBBEAN • GULF OF MEXICO • HURRICANE TRACK CHART
2004
NUMBER TYPE NAME DATE
1 H ALEX 31Jul.–6 Aug.
2 T BONNIE 3–13 Aug.
3 H CHARLEY 9–14 Aug.
4 H DANIELLE 13–21 Aug.
5 T EARL 13–15 Aug.
6 H FRANCES 25 Aug.–8 Sep.
7 H GASTON 27 Aug.–1 Sep.
8 T HERMINE 27–31 Aug.
9 H IVAN 2–24 Sep.
10 H JEANNE 13–28 Sep.
11 H KARL 16–24 Sep.
12 H LISA 19 Sep.–3 Oct.
13 T MATTHEW 8–10 Oct.
14 ST NICOLE 10–11 Oct.
15 T OTTO 29 Nov.–3 Dec.
Hurricane (H)
Tropical Storm (T)
Tropical Dep.
Extratropical
Wave/Low
Subtropical Depression
Subtropical Storm (ST)
Position at 0000 UTC
Position/date at 1200 UTC
Tropical Cyclone Number
Lambert Conformal Conic true at 20° and 40° North
North
South
5° West 0° East

How Active Was 2004?

North Atlantic Hurricane Activity 2004				
	Total ACE Index	Named Storms	Hurricanes	Intense Hurricanes
Average (±SD) 1950-2003	95 (±54)	9.9 (±3.3)	6.0 (±2.3)	2.5 (±1.9)
Actual 2004	228	15	9	6

The NOAA total ACE (Accumulated Cyclone Energy) index is the sum of the squares of all 6-hourly maximum sustained wind speeds (in units of knots) for all North Atlantic systems while they are at least tropical storm in strength. ACE unit = x 10^4 knots^2.

North Atlantic hurricane activity ~ 2 standard deviations above average.

How Active Was 2004?

US Landfalling Hurricane Activity 2004			
	US ACE Index	Named Storms	Hurricanes
Average (±SD) 1950-2003	2.2 (±2.0)	3.0 (±1.9)	1.4 (±1.2)
Actual 2004	6.6	8	5

The US ACE (Accumulated Cyclone Energy) index is the sum of the squares of hourly maximum sustained wind speeds (in units of knots) for all systems while they are at least tropical storm in strength and over the US mainland (reduced by a factor of 6). US ACE unit = x 10^4 knots^2.

US landfalling hurricane activity 2-3 standard deviations above average.

2004 US Hurricane Losses

Individual Storm and US Insured Loss Summary 2004

No.	Name	Dates	Peak Wind (kts)	Hurricane Category	Category at US Landfall	US Insured Loss (US $ bn)**
1	Alex	31 Jul - 6 Aug	105	3	-	0.0025
2	Bonnie	9-12 Aug	55	-	TS	-
3	Charley	9-15 Aug	125	4	4	7.475
4	Danielle	13-21 Aug	90	2	-	-
5	Earl	13-15 Aug	45	-	-	-
6	Frances	25 Aug - 9 Sep	125	4	2	4.595
7	Gaston	27 Aug - 1 Sep	65	1	1	0.065
8	Hermine	29 - 31 Aug	50	-	TS	-
9	Ivan	2 - 24 Sep	145	5	3	7.110
10	Jeanne	13 - 28 Sep	105	3	3	3.440
11	Karl	16 - 24 Sep	120	4	-	-
12	Lisa	19 Sep - 3 Oct	65	1	-	-
13	Matthew	8 - 10 Oct	40	-	TS	
14	Nicole*	10 - 11 Oct	45	-	-	-
15	Otto	29 Nov - 3 Dec	45	-	-	-

** Subtropical storm* ***Insurance Information Institute (expressed in 2004 dollars)*

2004 total hurricane insured loss now US $ 22.7 bn

Most Costly US Insured Losses

Ten Most Costly US Catastrophes			
Rank	Peril	Date	Insured Loss (US $ bn)**
1	Hurricane Andrew	Aug 1992	20,870
2	9/11 Terrorist Attacks	Sep 2001	20,050
3	Northridge Earthquake	Jan 1994	15,930
4	Hurricane Charley	Aug 2004	7,475
5	Hurricane Ivan	Sep 2004	7,110
6	Hurricane Hugo	Sep 1989	6,390
7	Hurricane Frances	Sep 2004	4,595
8	Hurricane Jeanne	Sep 2004	3,440
9	Hurricane Georges	Sep 1998	3,360
10	Tropical Storm Allison	Jun 2001	2,670

***Insurance Information Institute (expressed in 2004 dollars)*

2004 - Notable Features

1. Four hurricanes (three of which were intense) struck Florida. This is the first time since 1886 that four hurricanes have hit the same state.

2. Hurricane Charley was the most intense hurricane to strike the US since Andrew in 1992.

3. Following the interval of low hurricane damage between 2000 and 2002 (when just one hurricane made U.S. landfall), 2003 and 2004 have seen the third highest two-year total number of U.S. hurricane landfalls (7) since 1900.

Where Does 2004 Rank?

North Atlantic ACE (Accumulated Cyclone Energy) index:

2nd highest (after 1950) since 1950.

U.S. ACE index:

4th highest since 1950 and 8th highest since 1900.

Number of U.S. hurricane landfalls

Equal 3rd highest (after 1916 and 1985) since 1900.

U.S. hurricane total insured loss:

3rd highest (after 1926 and 1992) since 1900.

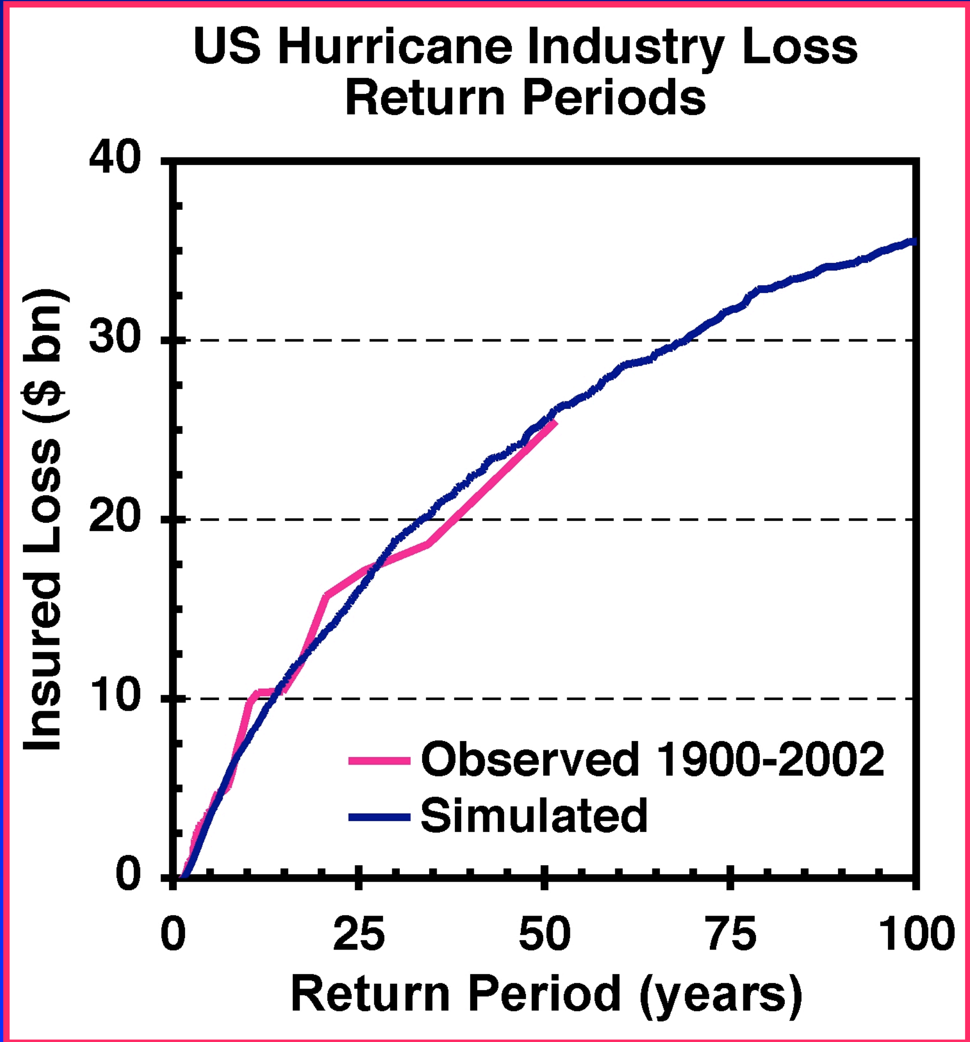
Return Periods - 2004

U.S. hurricane strikes (5 or more):

33 years.

U.S. hurricane total insured loss (US $ 22.7bn):

37 years (see opposite).



Hilti, Saunders and Lloyd-Hughes (2004)

Why Was 2004 So Active?

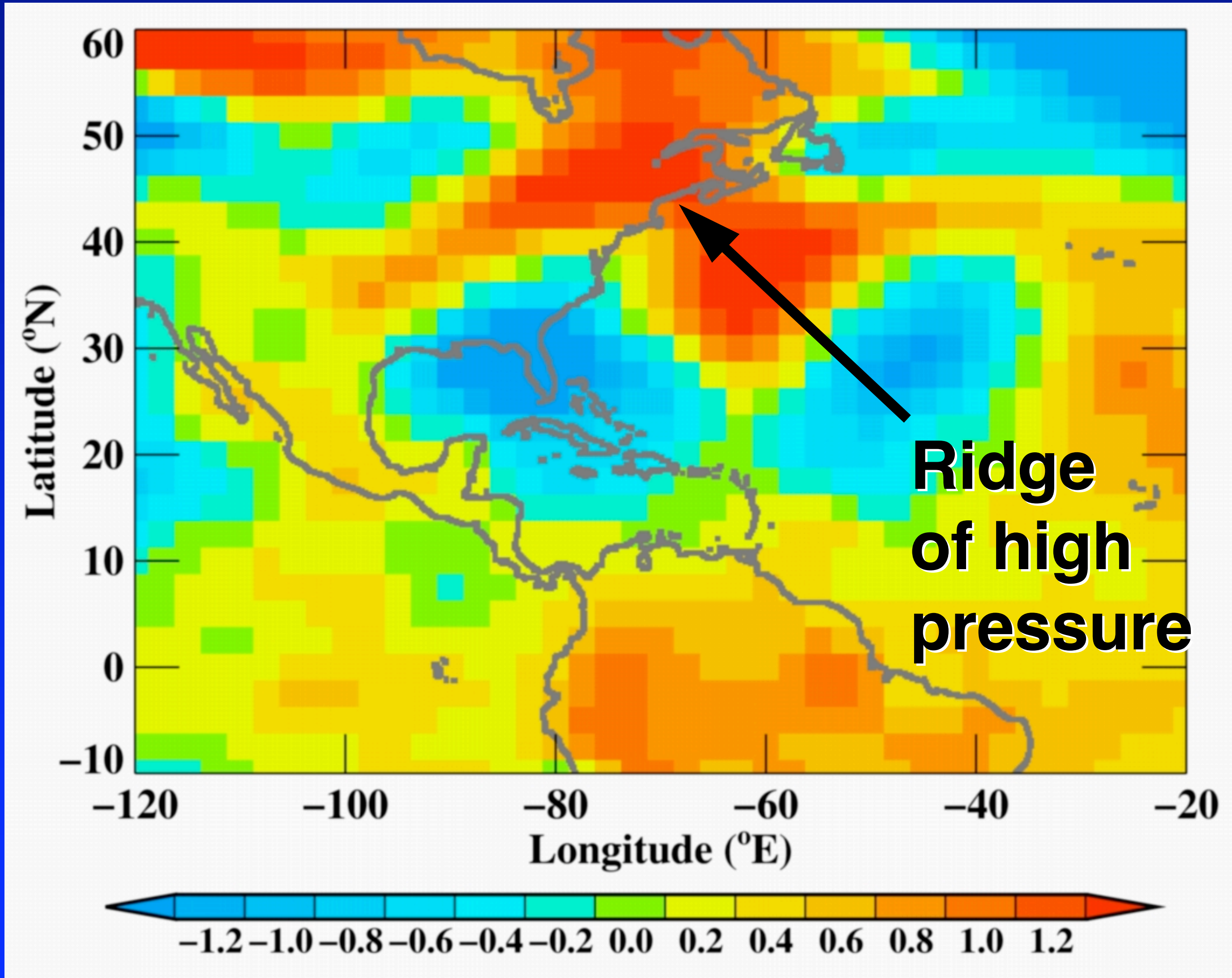
1. US Landfalling Hurricane Activity

Tropospheric ‘steering winds favored increased US hurricane landfalls due to ridge of high pressure over northeast US persisting during August and September 2004.

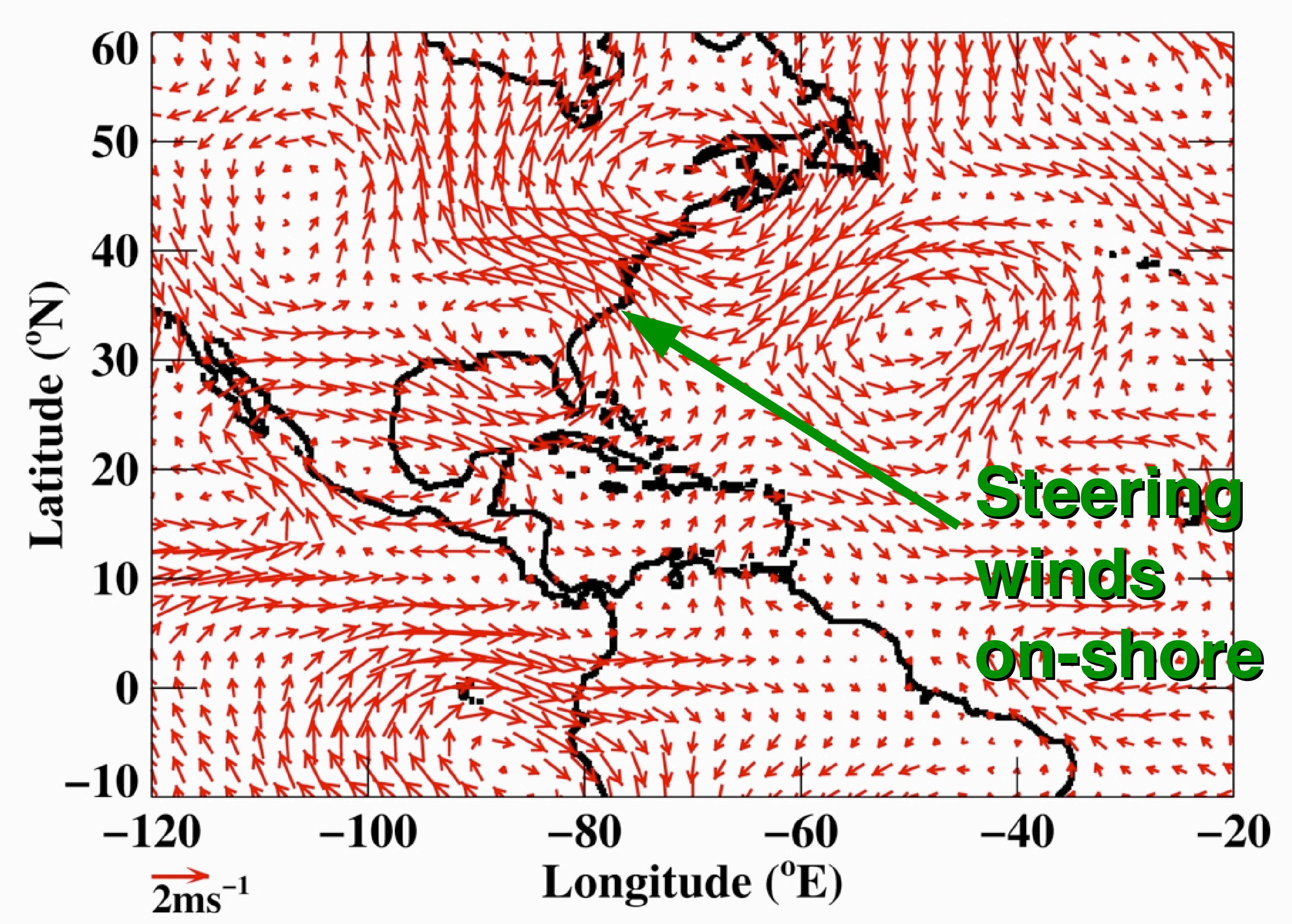
2. North Atlantic Hurricane Activity

Weaker than normal trade winds, higher than normal sea surface temperatures and below average vertical wind shear all contributed to the unusually high Atlantic hurricane activity.

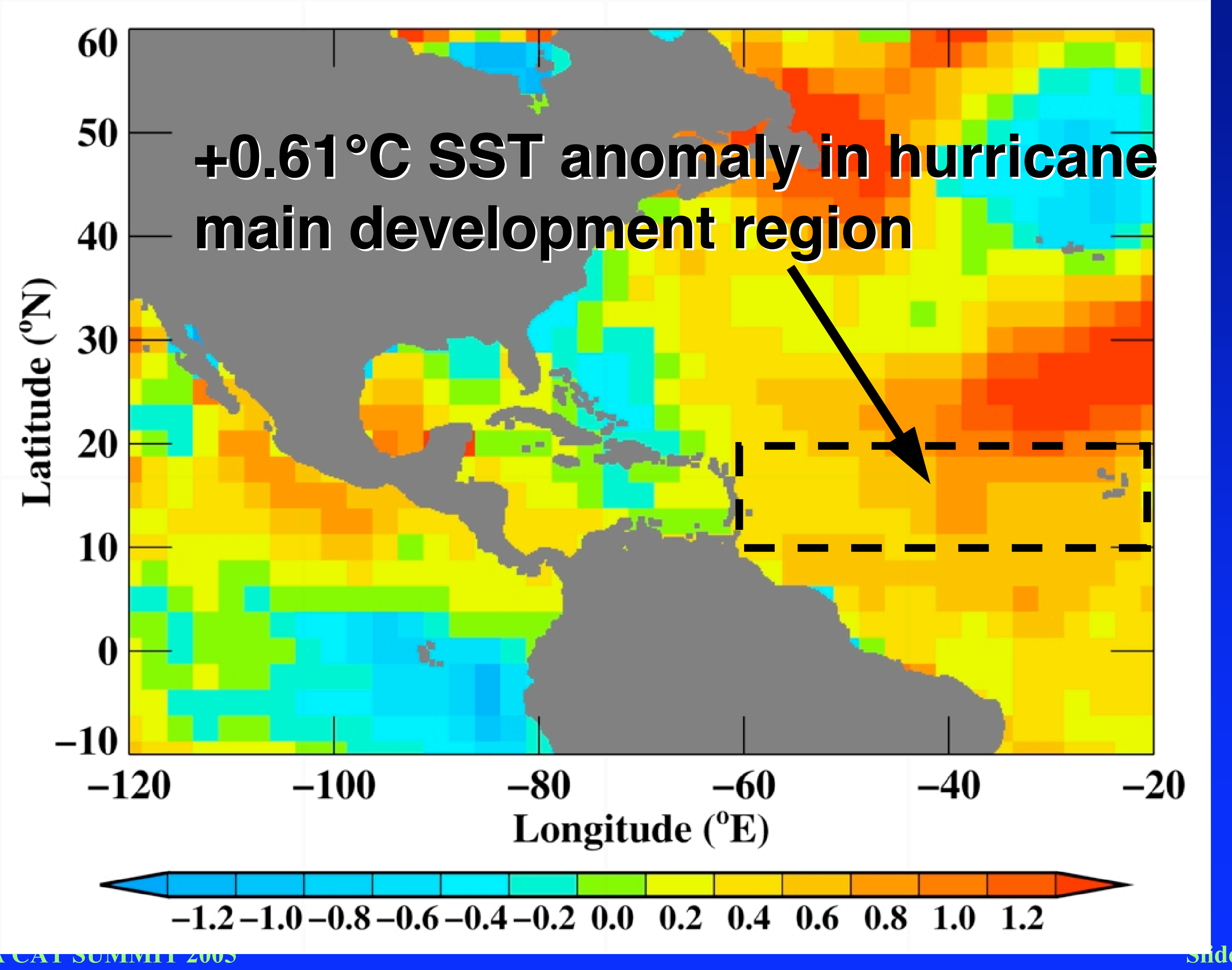
AS 2004 Mean Sea Level Pressure Anomaly



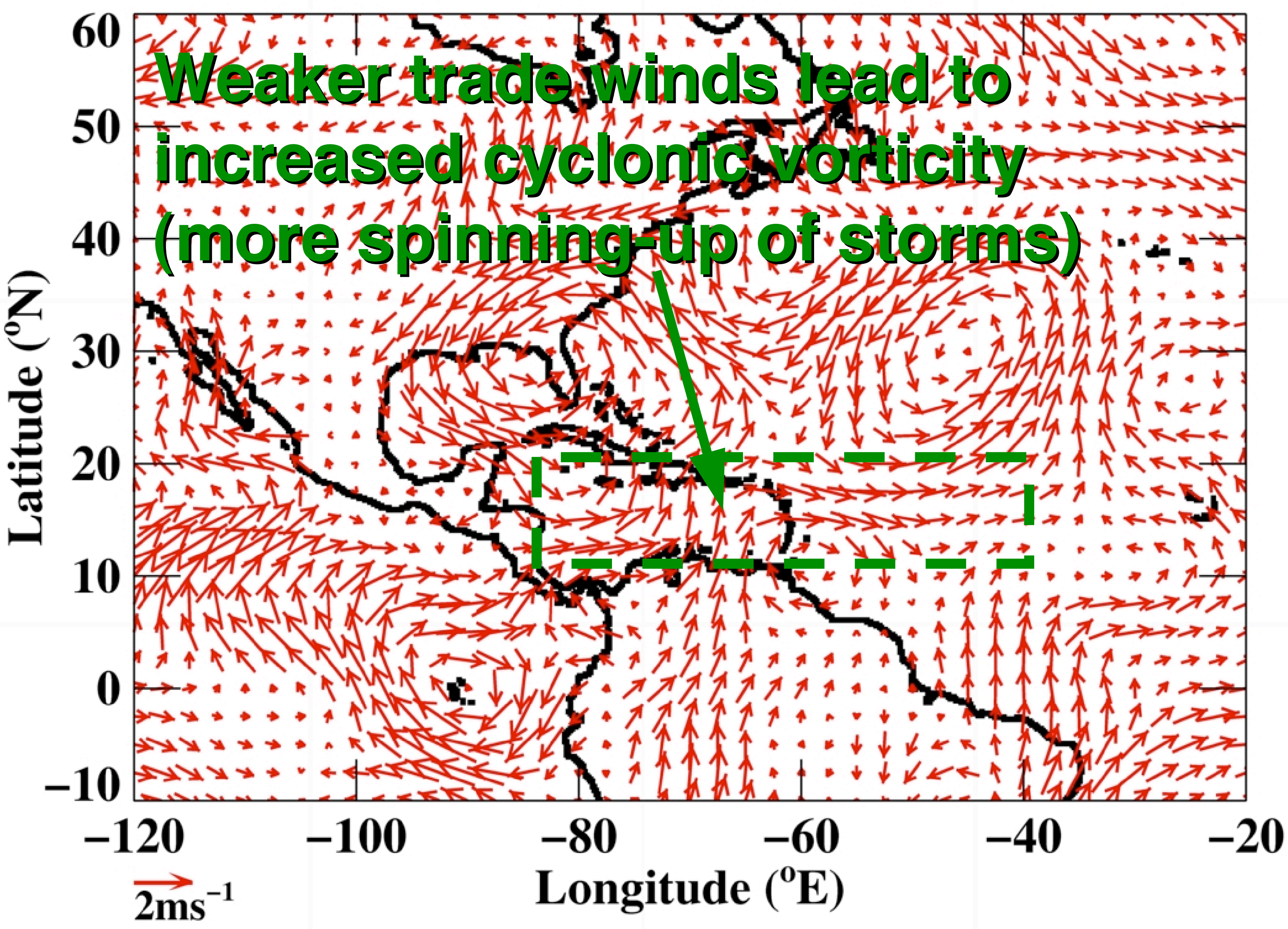
AS 2004 Tropospheric Height-Averaged Wind Anomalies



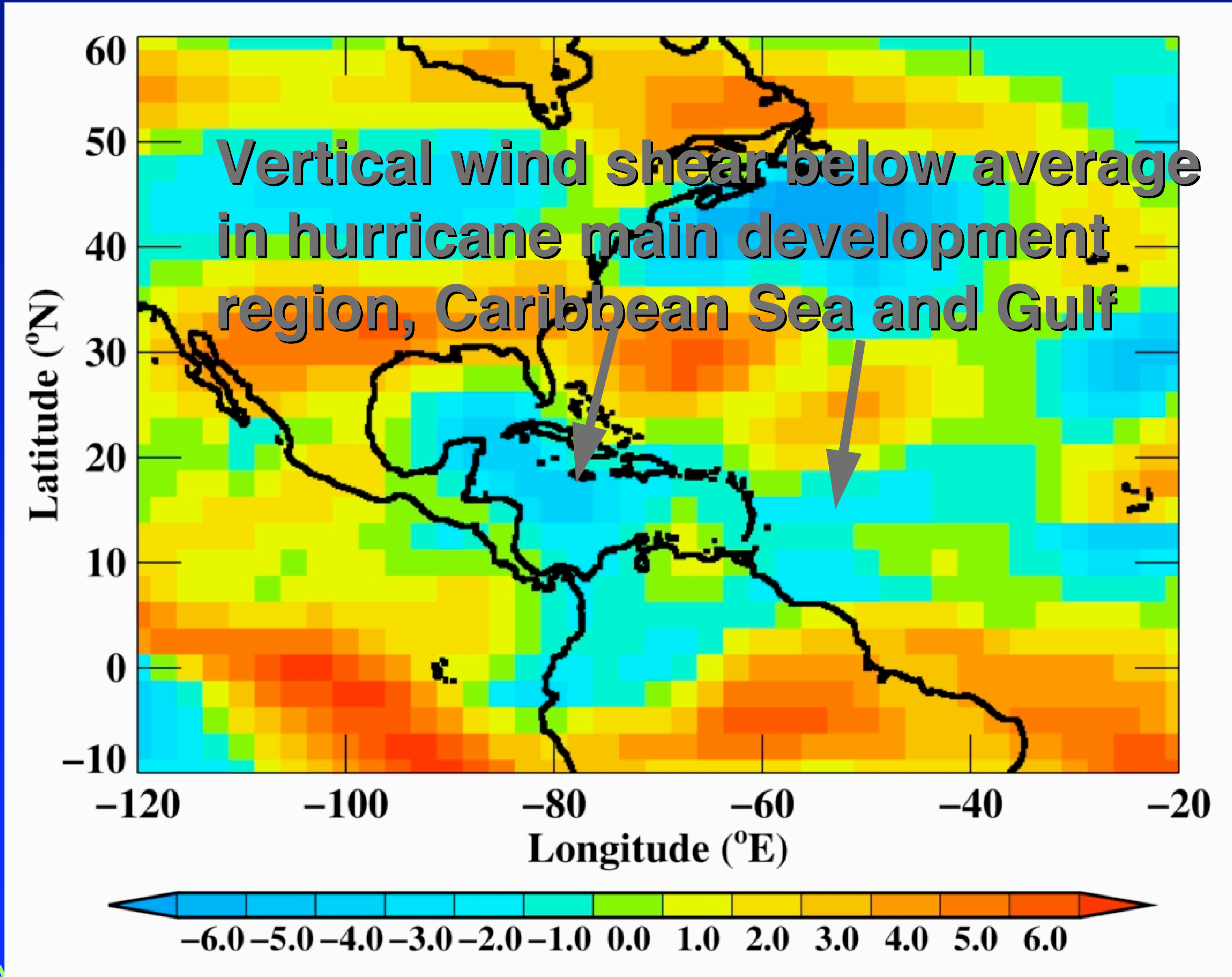
AS 2004 Sea Surface Temp Anomaly



AS 925mb Wind Anomaly



AS Vertical Wind Shear Anomaly



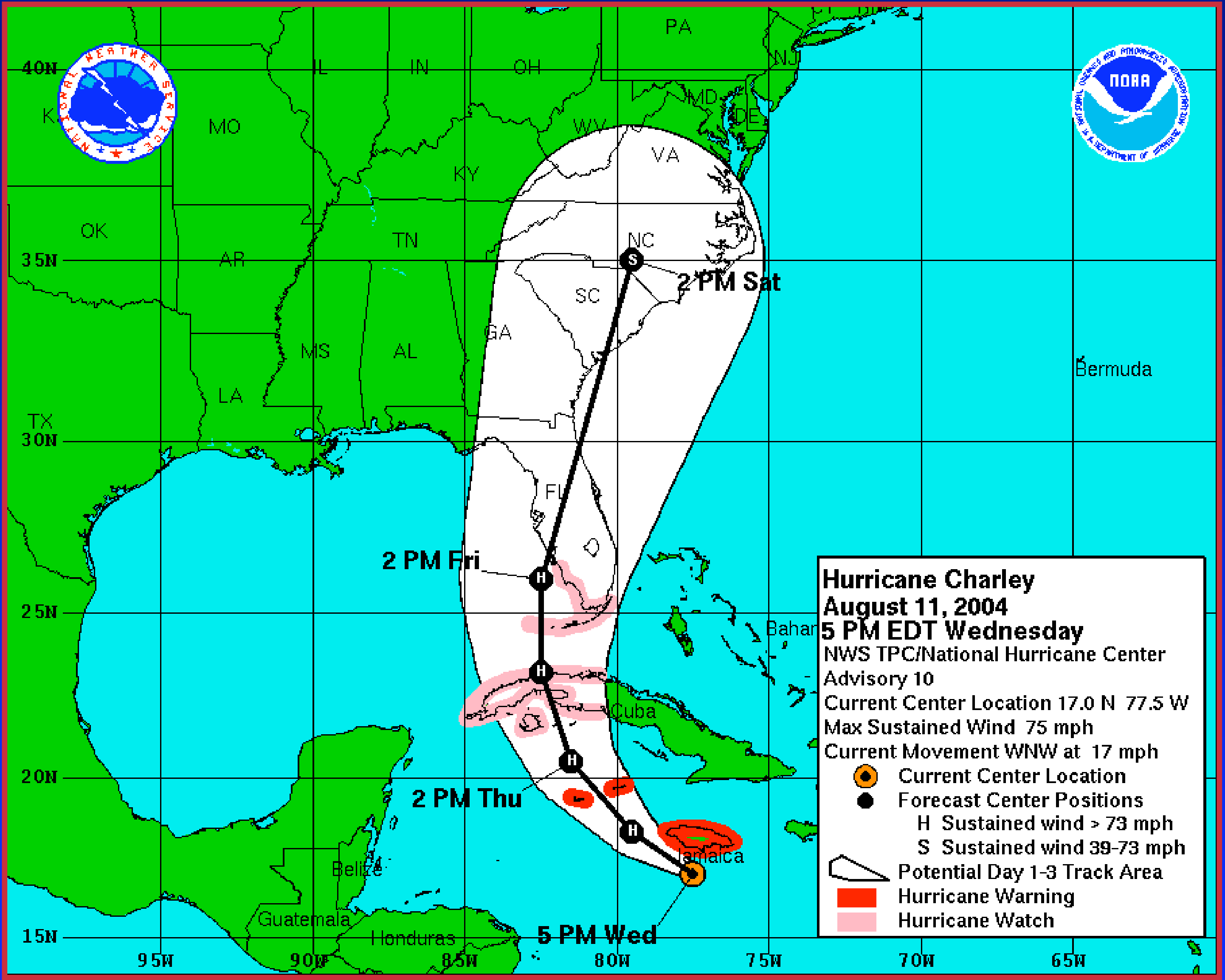
2. How Well Was 2004 Hurricane Activity Predicted?

a) Short/medium range forecasts

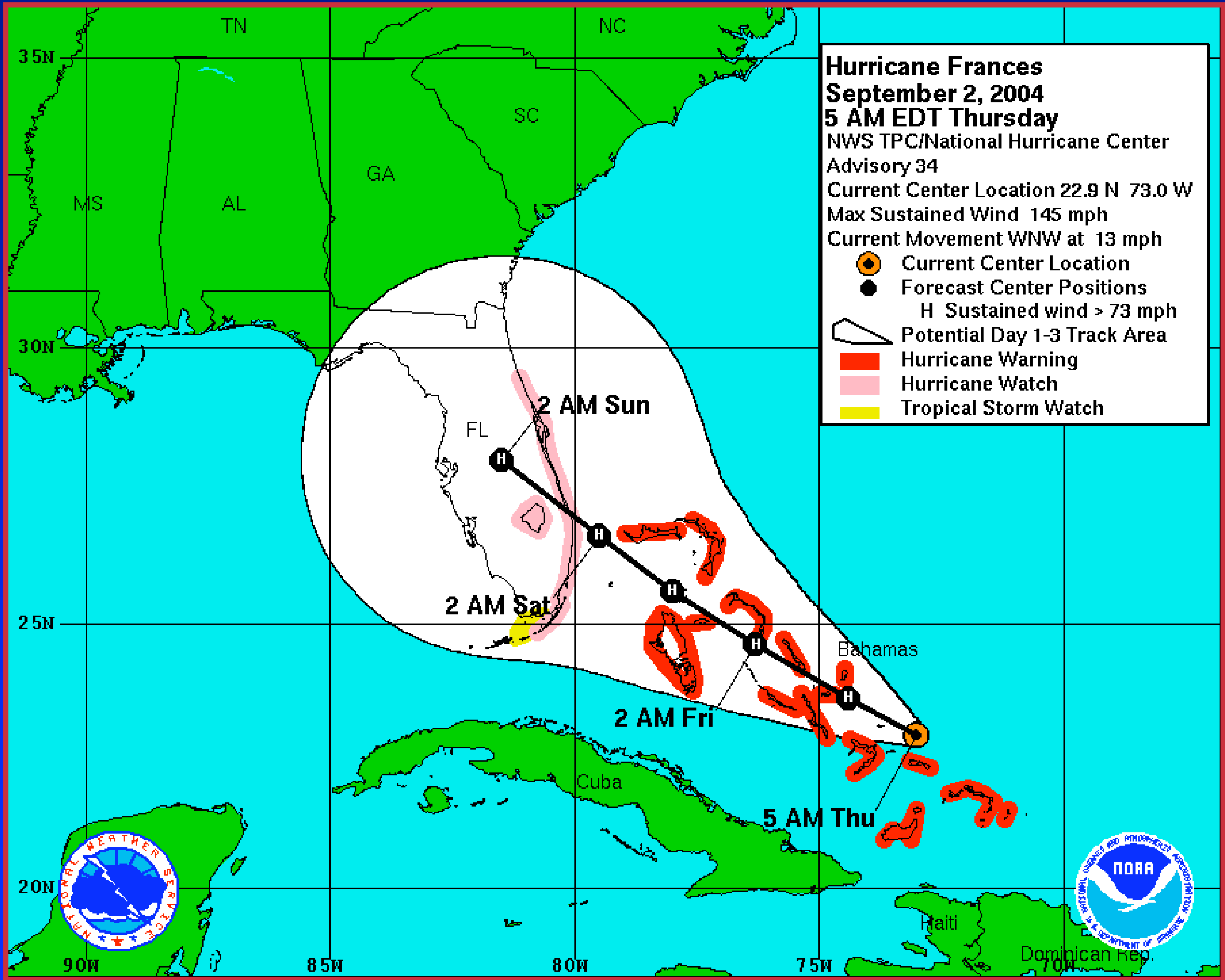
b) Seasonal forecasts

c) Benefits of forecasts

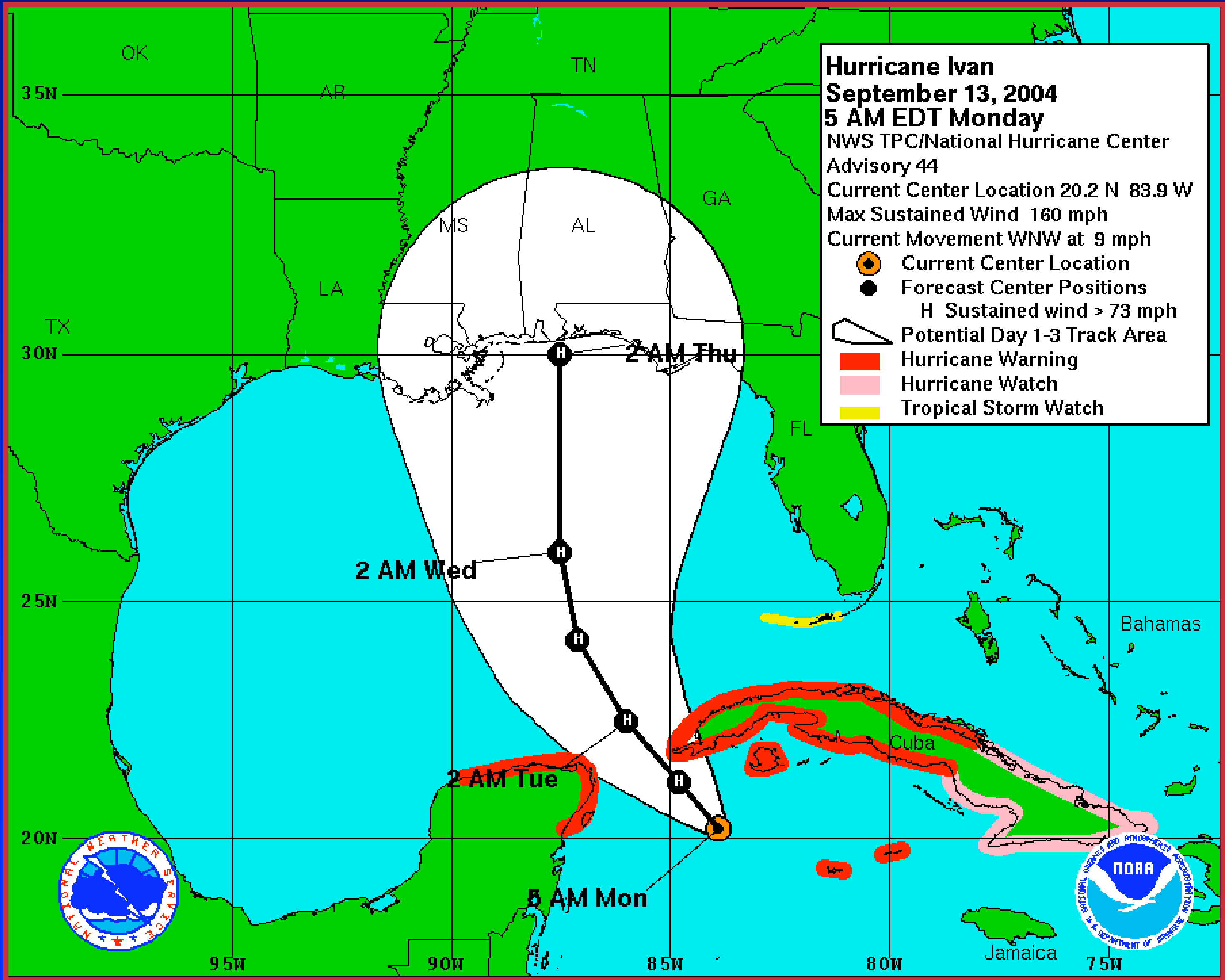
Charley landfall forecast (45 hrs lead)



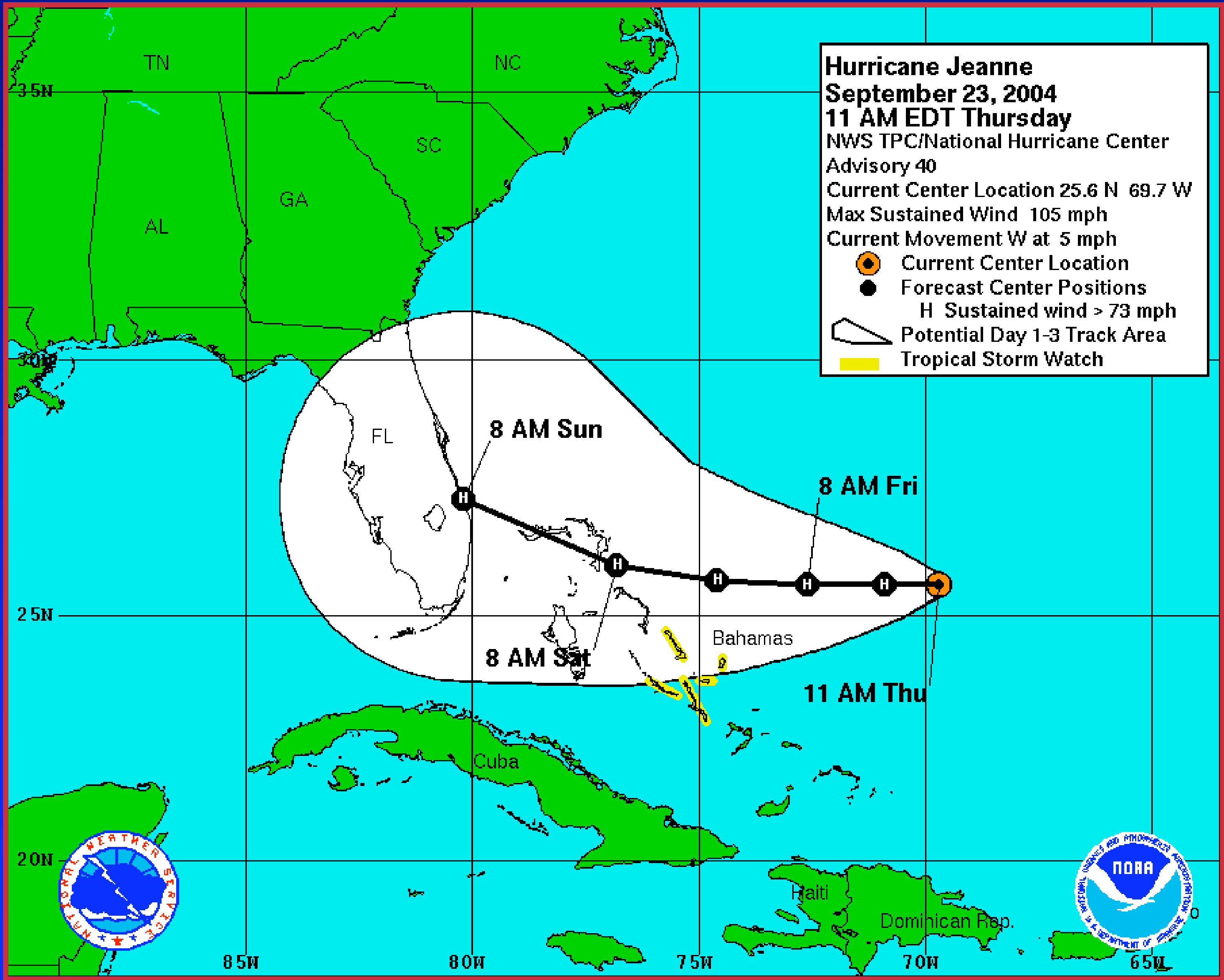
Frances landfall forecast (45 hrs lead)



Ivan landfall forecast (69 hrs lead)



Jeanne landfall forecast (69 hrs lead)



Summary of Selected 2004 Landfall Predictions

Skill of 2004 Hurricane Landfall Forecasts				
Hurricane	Forecast lead time (hrs)	Landfall positional error (km)	Landfall intensity error (kts)	Landfall timing error (hrs)
Charley	45	14	-40	0
Frances	45	35	+35	+16
Ivan	69	16	0	0
Jeanne	69	11	-10	-8

Intensity error: - (forecast landfall intensity low), + (forecast intensity high)
Timing error: - (forecast landfall time early), + (forecast landfall time late).

Skill of 2003 US Hurricane Landfall Forecasts

Major hurricane strikes in 2003 were also forecast successfully at leads of 2-3 days:

Fabian - direct hit on Bermuda predicted correctly at **lead of 45 hours** to within 20km and 4 hours.

Isabel - US landfall forecast correctly at a **lead of 69 hours** to within 20km and 1 hour.

Juan - strike on Nova Scotia predicted correctly at a **lead of 69 hours** to within 50km and one hour.

Benefits to Cat Risk Managers

The increasingly accurate forecasts of hurricane landfall position and landfall intensity offer scope for skillful probabilistic forecasts of hurricane 'value at risk' and insured loss.

Such probabilistic forecasts would offer:

1. *Improved claims management.*
2. *Improved shareholder confidence.*
3. *Improved cash flow management.*

Seasonal Forecasts - Verification (1)

Probabilistic Forecasts: North Atlantic Total ACE Index 2004					
		Tercile Probabilities			RPSS
		Below normal	Normal	Above normal	
Actual 2004		0	0	100	1
Climatology 1950-2003		33.3	33.3	33.3	0
TSR Forecasts	4 Aug 2004	1	13	86	0.95
	5 Jul 2004	7	38	55	0.47
	4 Jun 2004	13	46	41	0.13
	11 May 2004	7	32	61	0.61
	6 Apr 2004	9	26	65	0.70
	5 Mar 2004	13	27	60	0.62
	5 Feb 2004	7	21	72	0.81
	6 Jan 2004	12	23	65	0.72
	5 Dec 2003	12	23	65	0.72
NOAA Forecasts	7 Aug 2004	10	45	45	0.23
	19 May 2004	10	40	50	0.37

RPSS = Rank Probability Skill Score

Seasonal Forecasts - Verification (2)

Probabilistic Seasonal Forecasts: US ACE Index 2004					
		Tercile Probabilities			RPSS
		Below normal	Normal	Above normal	
Actual 2004		0	0	100	1
Climatology 1950-2003		33.3	33.3	33.3	0
TSR Forecasts	4 Aug 2004	5	25	70	0.77
	5 Jul 2004	8	34	57	0.54
	4 Jun 2004	11	40	49	0.35
	11 May 2004	6	31	63	0.65
	6 Apr 2004	6	27	67	0.72
	5 Mar 2004	6	30	64	0.67
	5 Feb 2004	3	22	75	0.83
	6 Jan 2004	6	26	68	0.74
	5 Dec 2003	6	26	68	0.74

RPSS = Rank Probability Skill Score

Benefits to US Property Catastrophe Reinsurance

- (Re)insurers would have reduced their losses in 2004 by acting upon the seasonal forecasts (above tercile activity predicted to high probability).

- Buyers and sellers of reinsurance covers can improve returns over a period of years by up to 30% by using seasonal hurricane forecasts (Hilti et al, 2004).

Ref: Hilti, N., Saunders, M. A. & Lloyd-Hughes, B. Forecasting stronger profits. *Global Reinsurance*, July/August issue, 6-7 (2004).

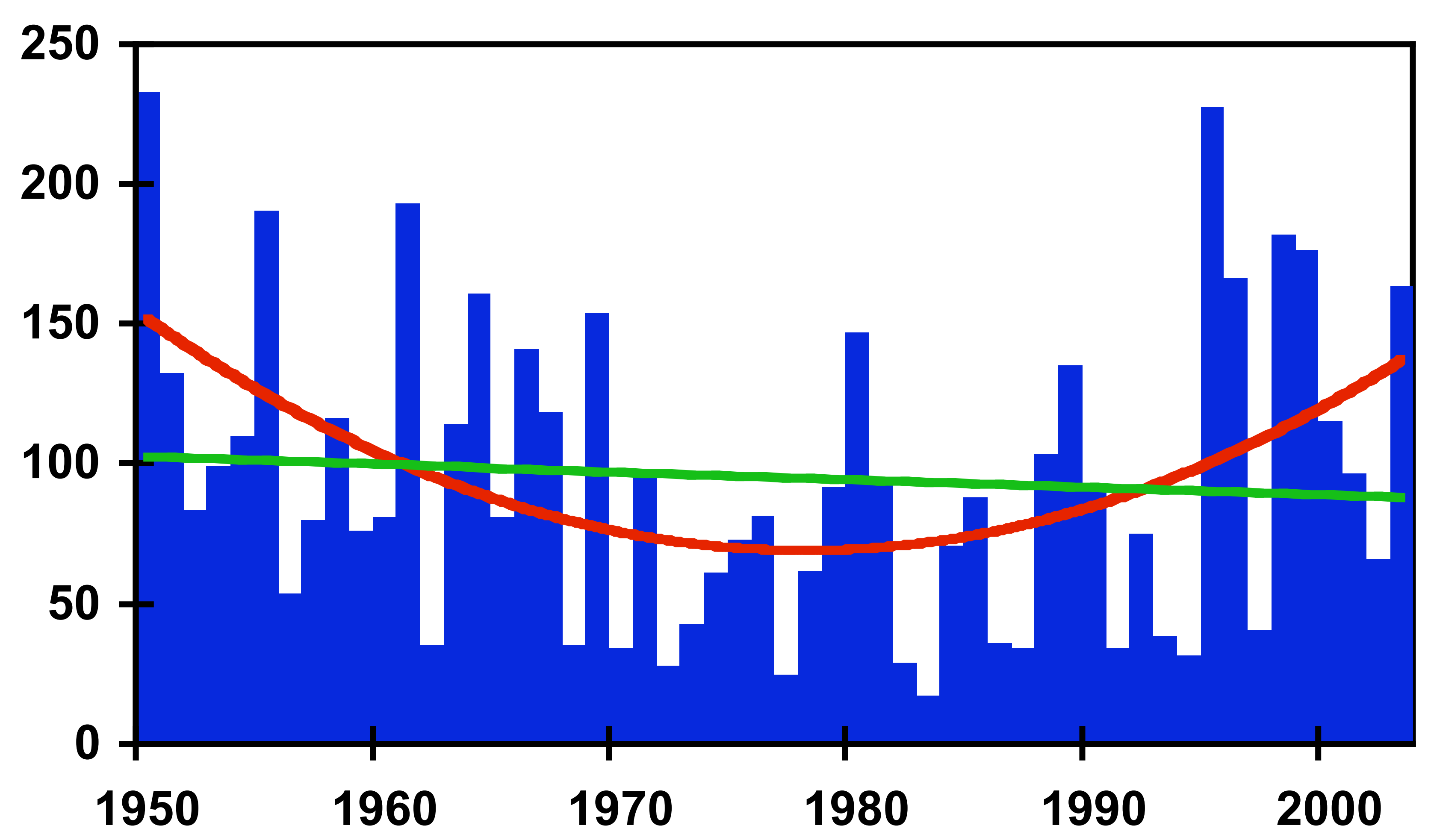
3. Anomaly or Trend?

a) US and Atlantic hurricane past activity.

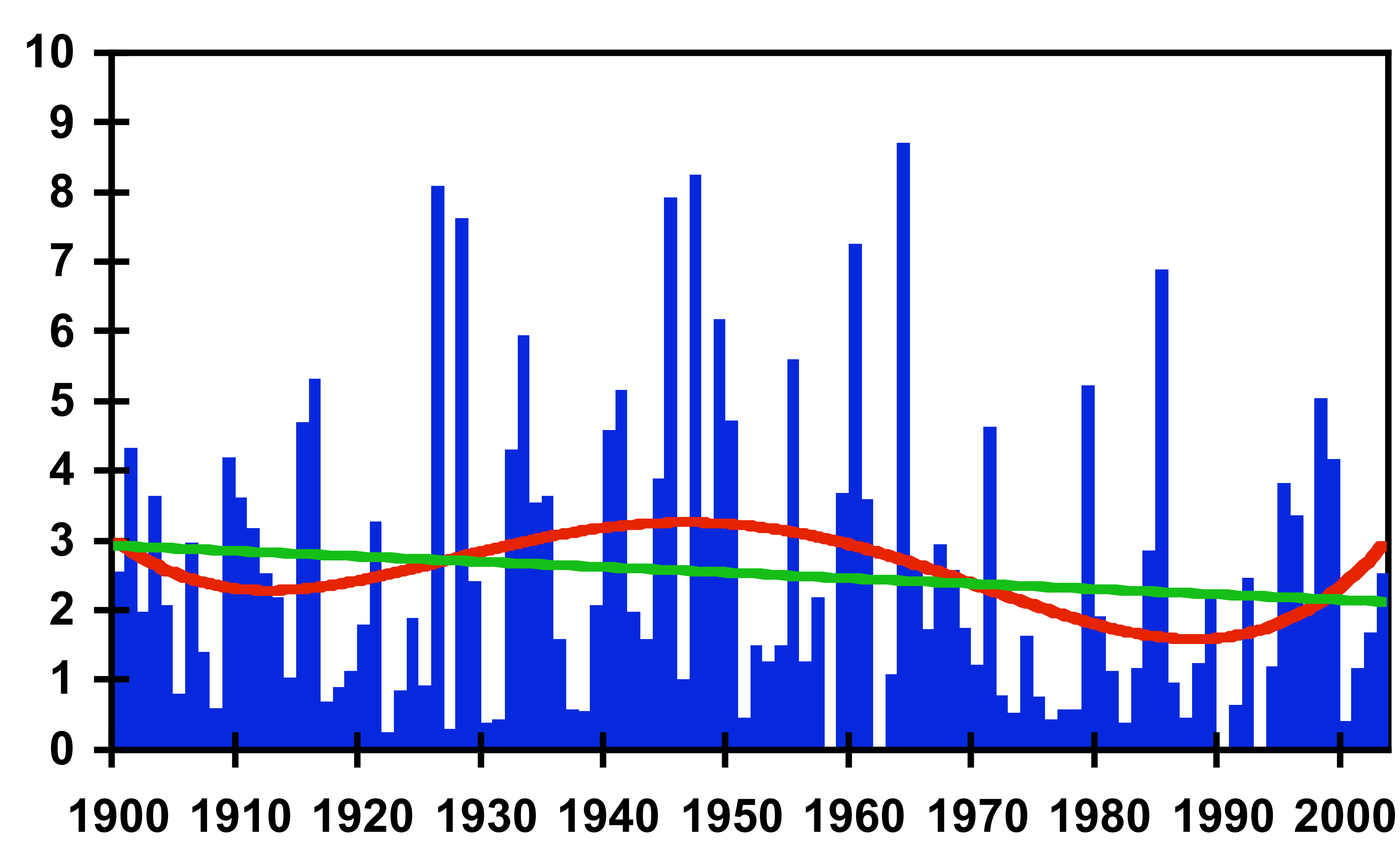
b) Global warming and future hurricane activity.

c) Conclusions

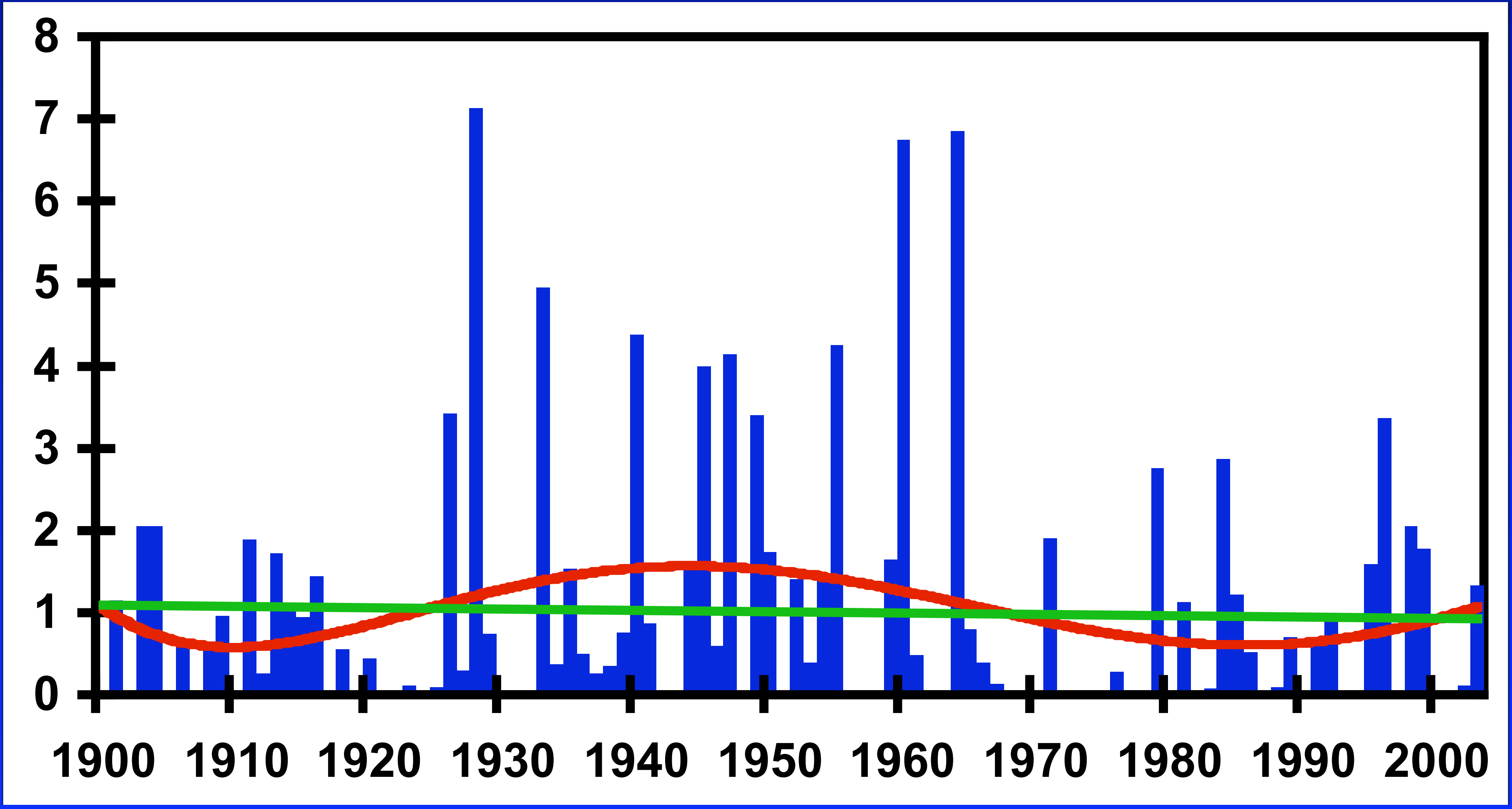
North Atlantic ACE index 1950-2003



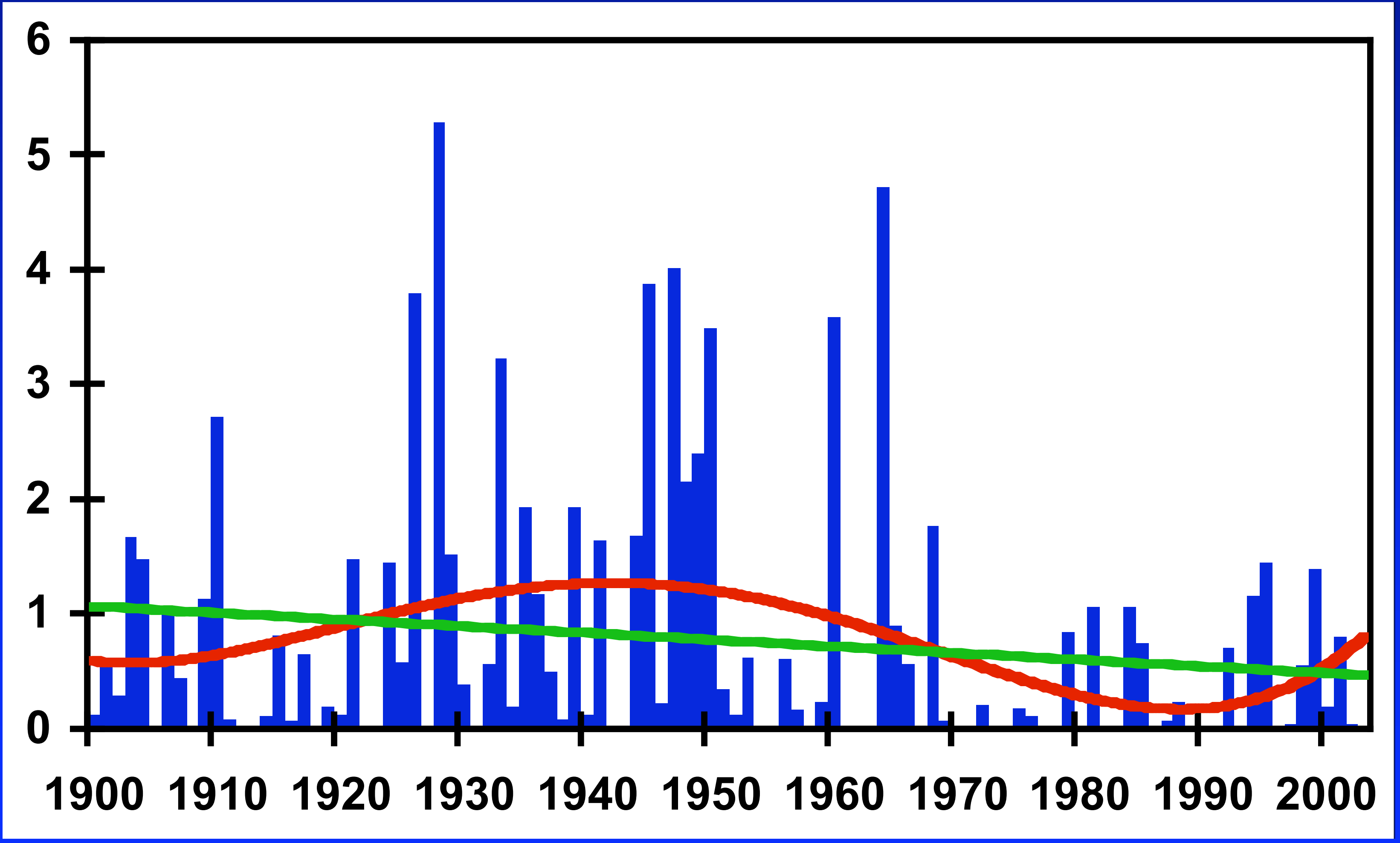
U.S. ACE index 1900-2003



U.S. East Coast ACE index 1900-2003



Florida ACE index 1900-2003



Significant Trend or Change in Variance?

- No significant change in ACE index or ACE index variance is observed anywhere either over the full period or when comparing the recent 1978-2003 period compared to other prior 26-year periods.

- The change in ACE index due to natural climate variability is an order of magnitude greater than that which may be attributable to trend in the historical record.

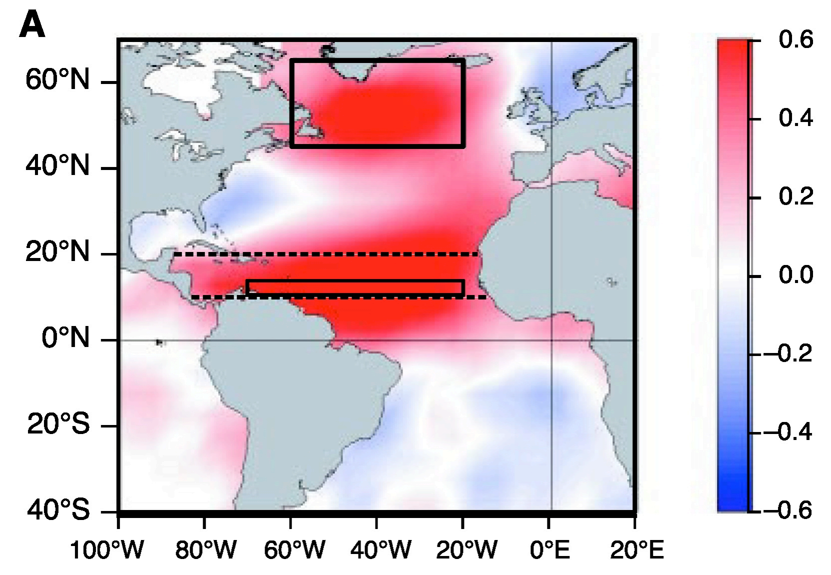
Conclusions

1. Global warming has, at present, had little or no increasing impact on northern hemisphere tropical cyclone activity.

2. Observed changes in activity are due predominantly to natural climate variability.

3. 2004 should be regarded as an anomaly rather than part of a trend caused by global warming.

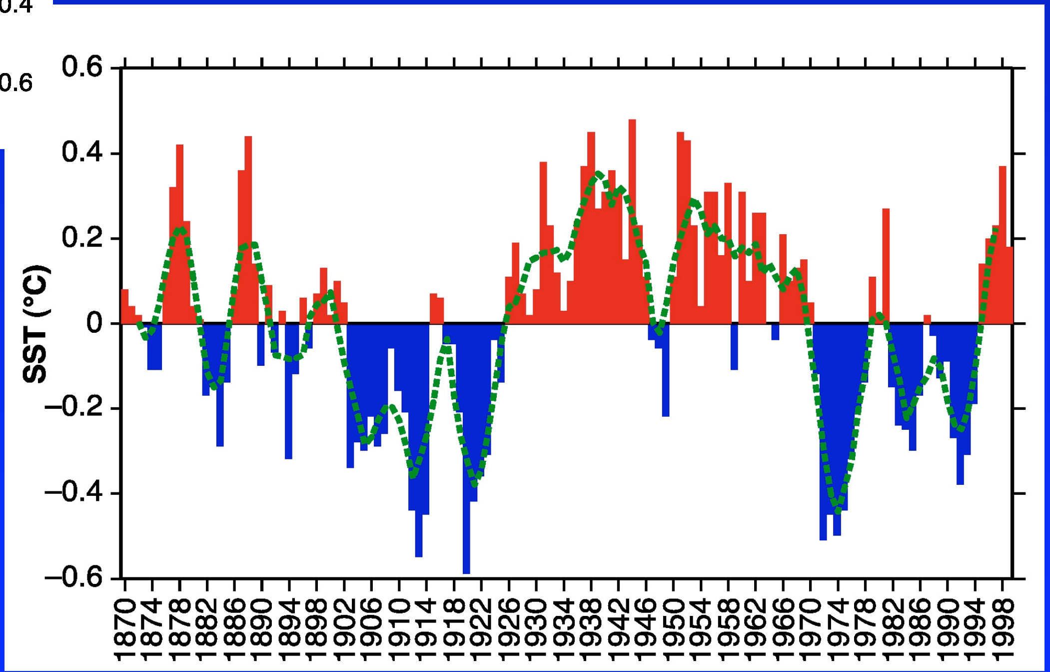
Multi-Decadal Variability



(Goldenberg et al., Science, 2001)

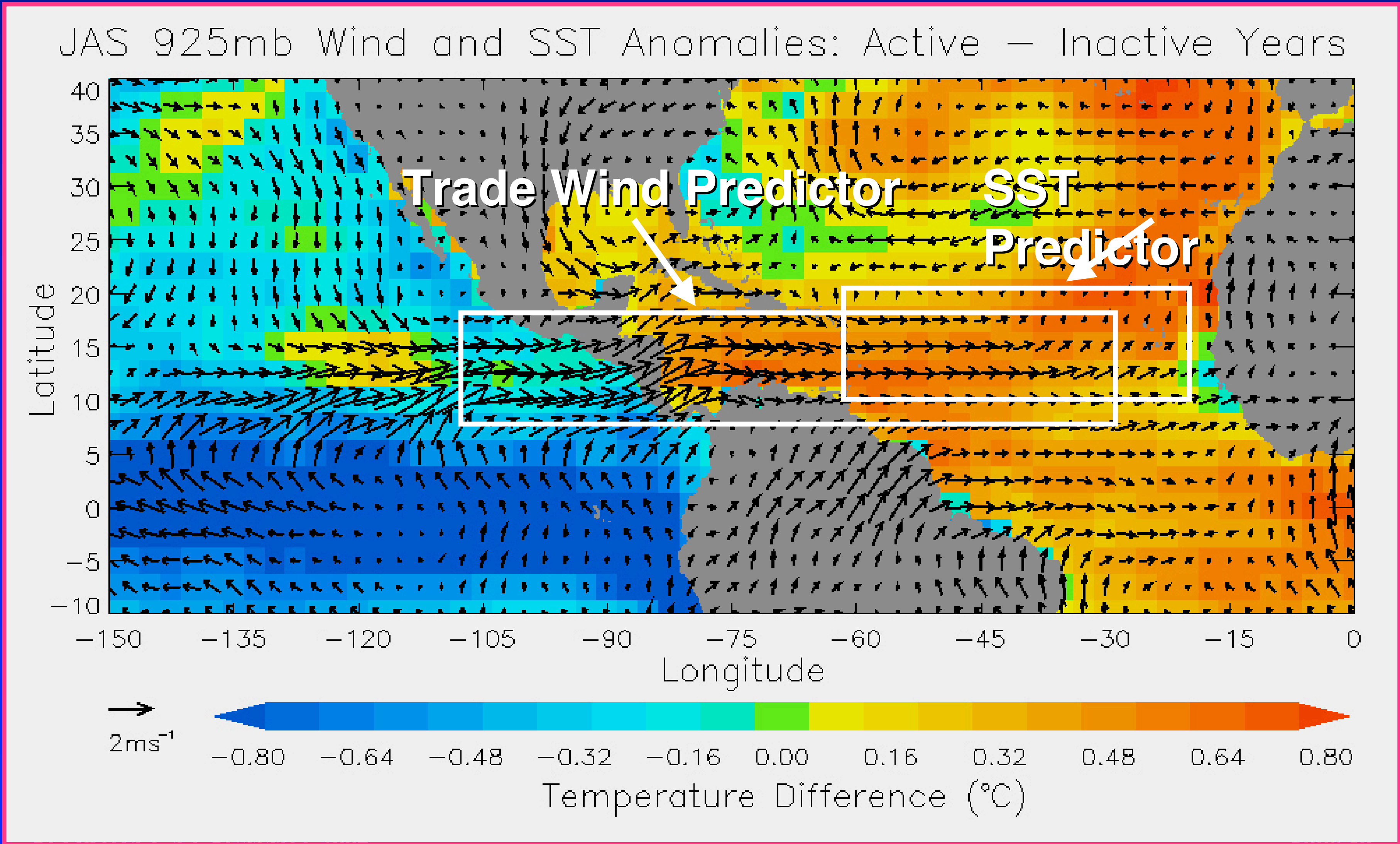
Leading mode of Atlantic non-ENSO SST variability 1870-2000.

Temporal reconstruction of SST mode-related variability for hurricane main development region.



What is our Current Understanding of How Tropical Cyclone Activity Will Vary in the Future?

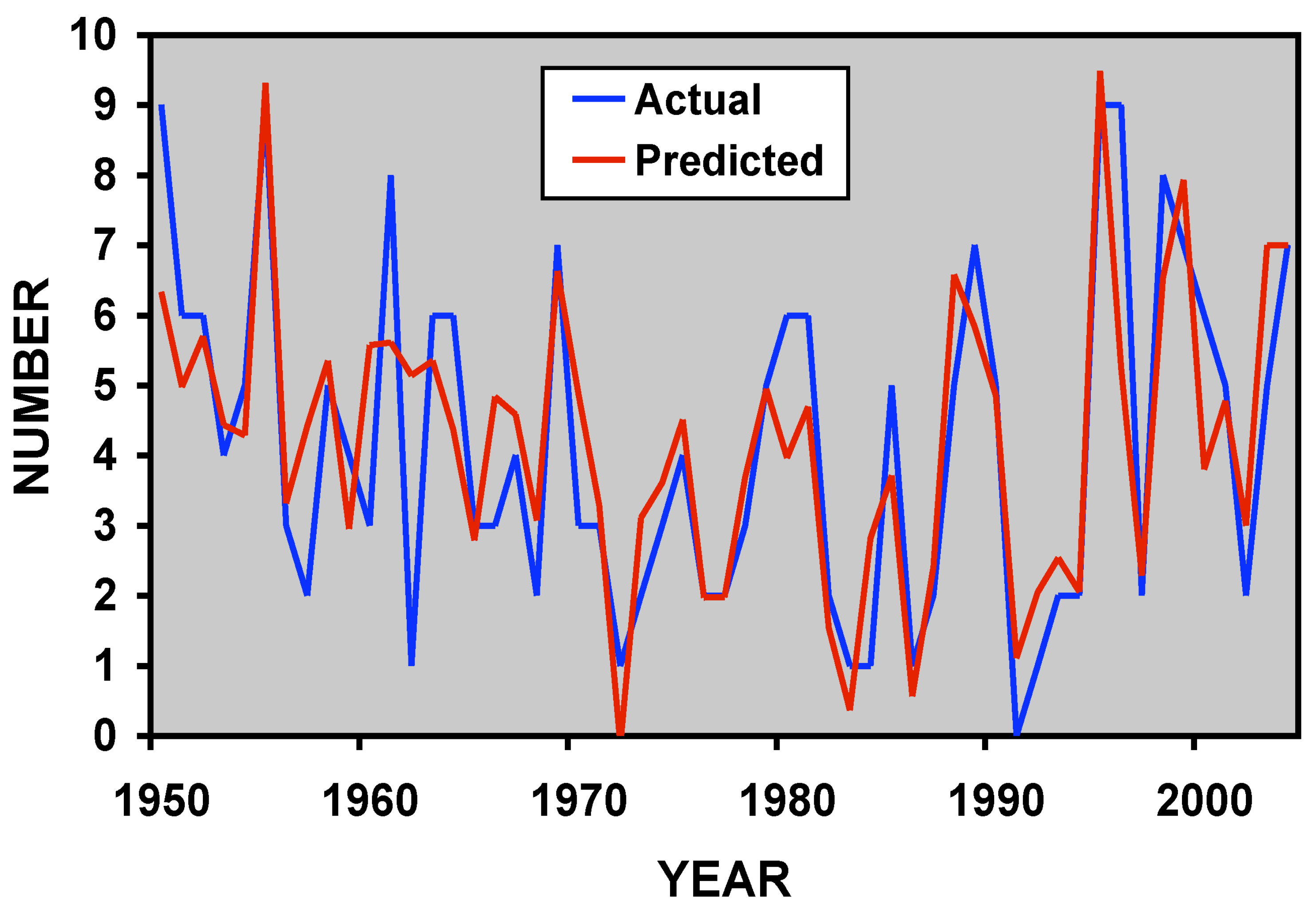
Atlantic Hurricane Predictors



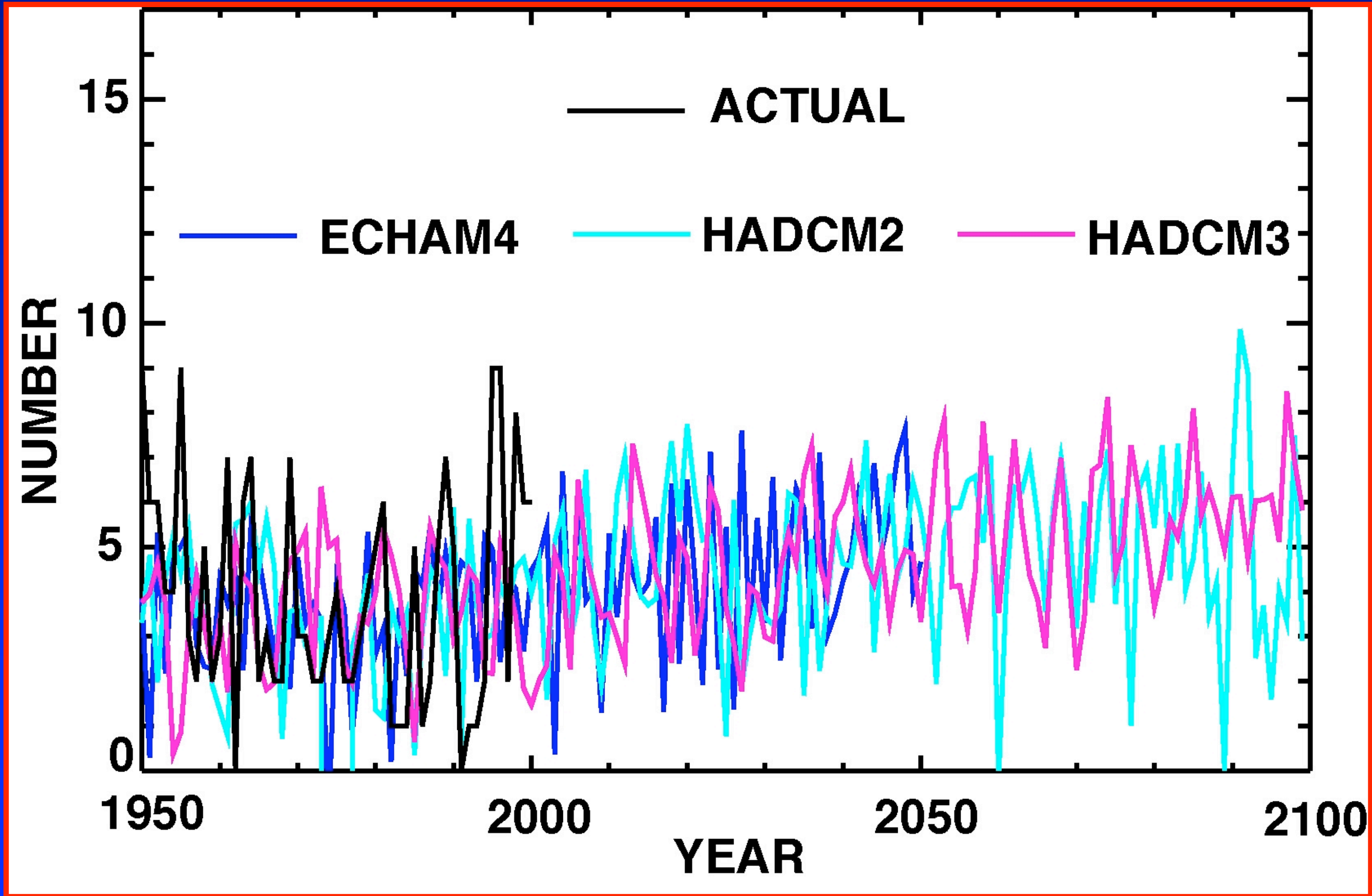
Hurricane Numbers 1950-2004
Tropical Atlantic, Caribbean Sea and Gulf

Perfect Predictors

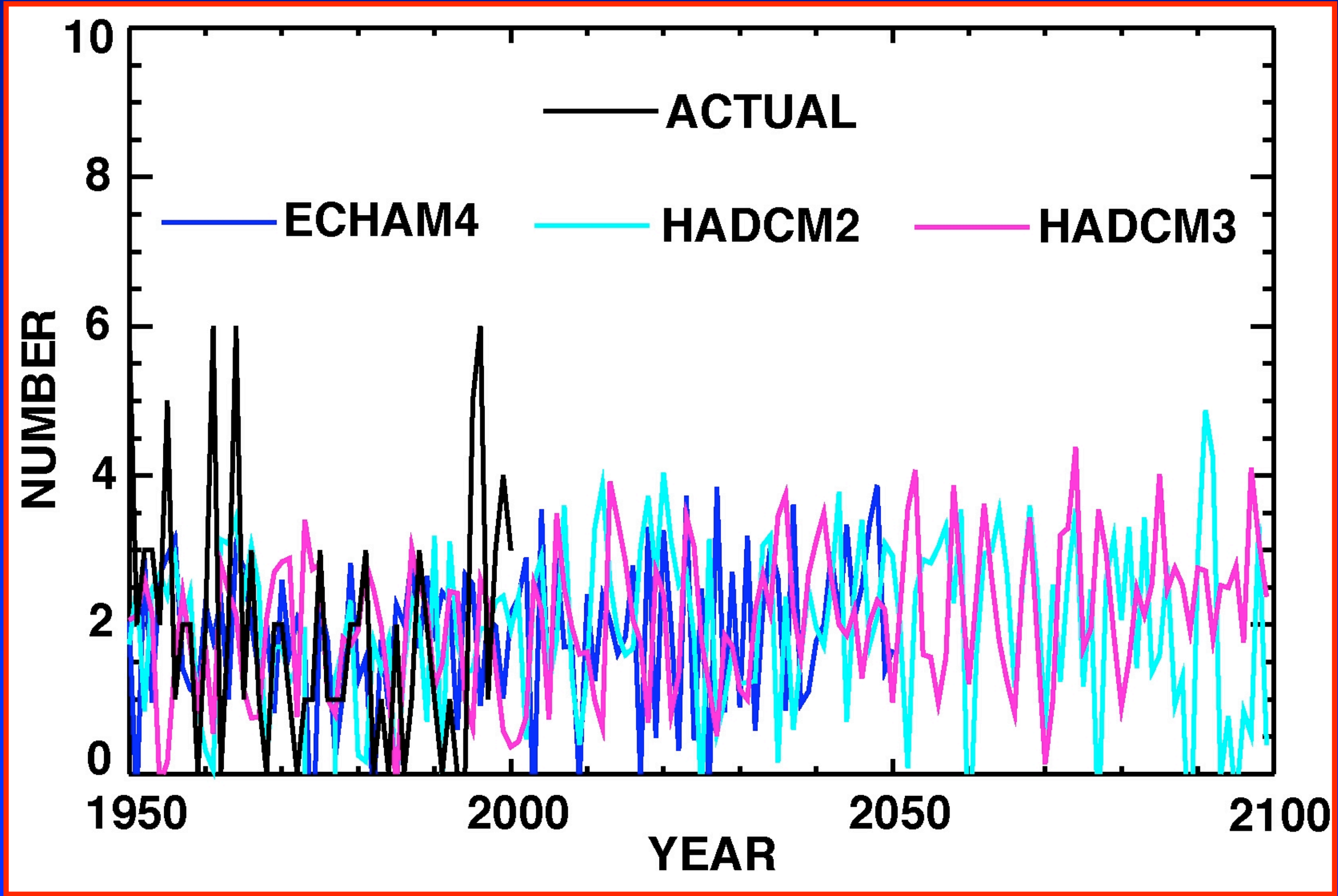
$R^2 = 0.67$



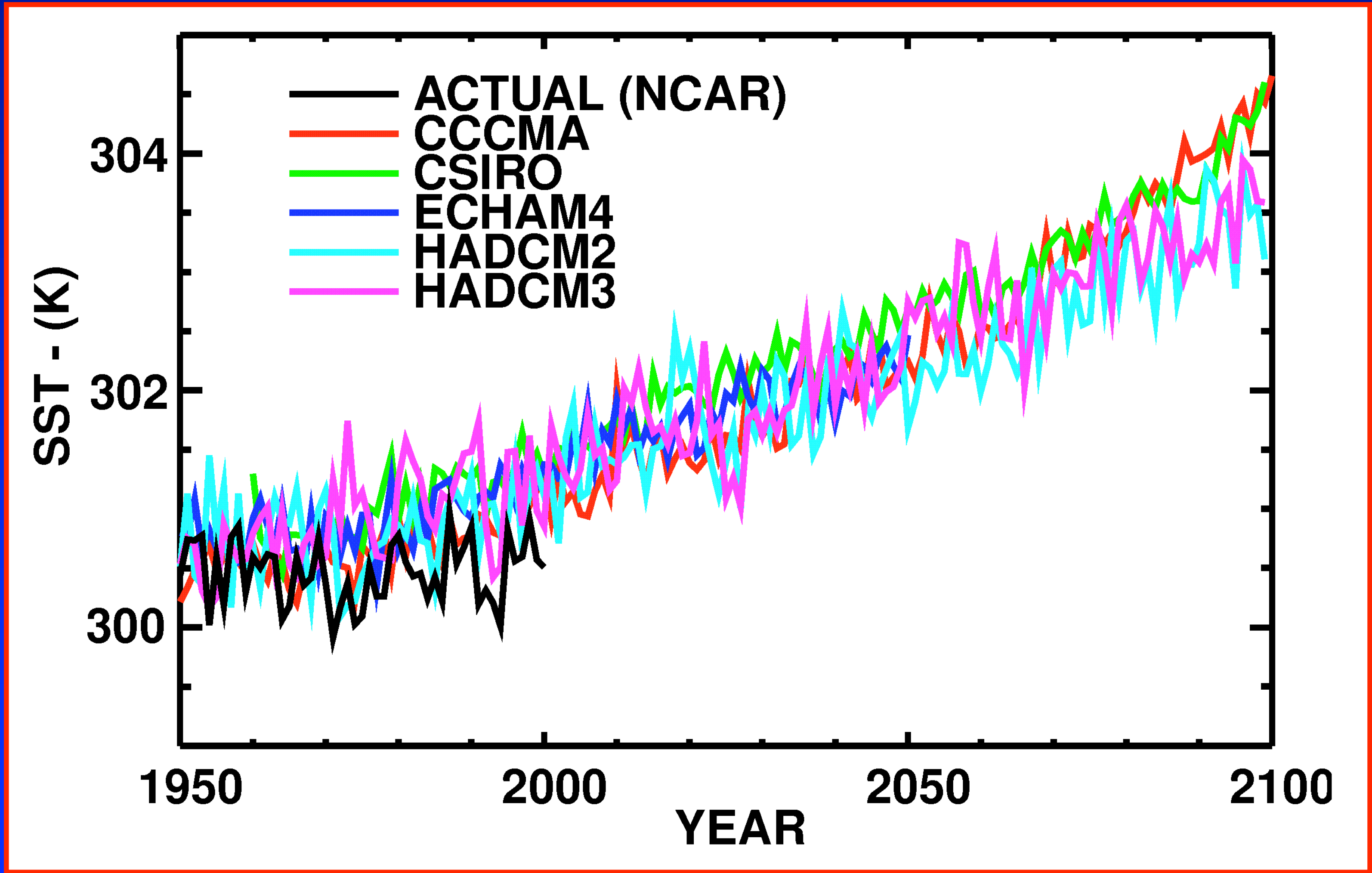
Future Projections for Tropical Atlantic, Caribbean and Gulf Hurricane Numbers



Future Projections for Tropical Atlantic, Caribbean and Gulf Intense Hurricane Nos



Future Projections for Tropical Atlantic SST



Hurricane Intensity

Knutson and Tuleya (2004) in a detailed GCM modeling study predict:

1. 6% increase in hurricane maximum intensity with an 80% increase in CO_2. This is line with theoretical estimates by Emanuel.

2. 18% increase in mean precipitation rate within 100km of the storm centre.

These changes may not be detectable for a few decades.

Conclusions

1. The number of North Atlantic, U.S. and Caribbean hurricanes may rise slowly due to global warming.

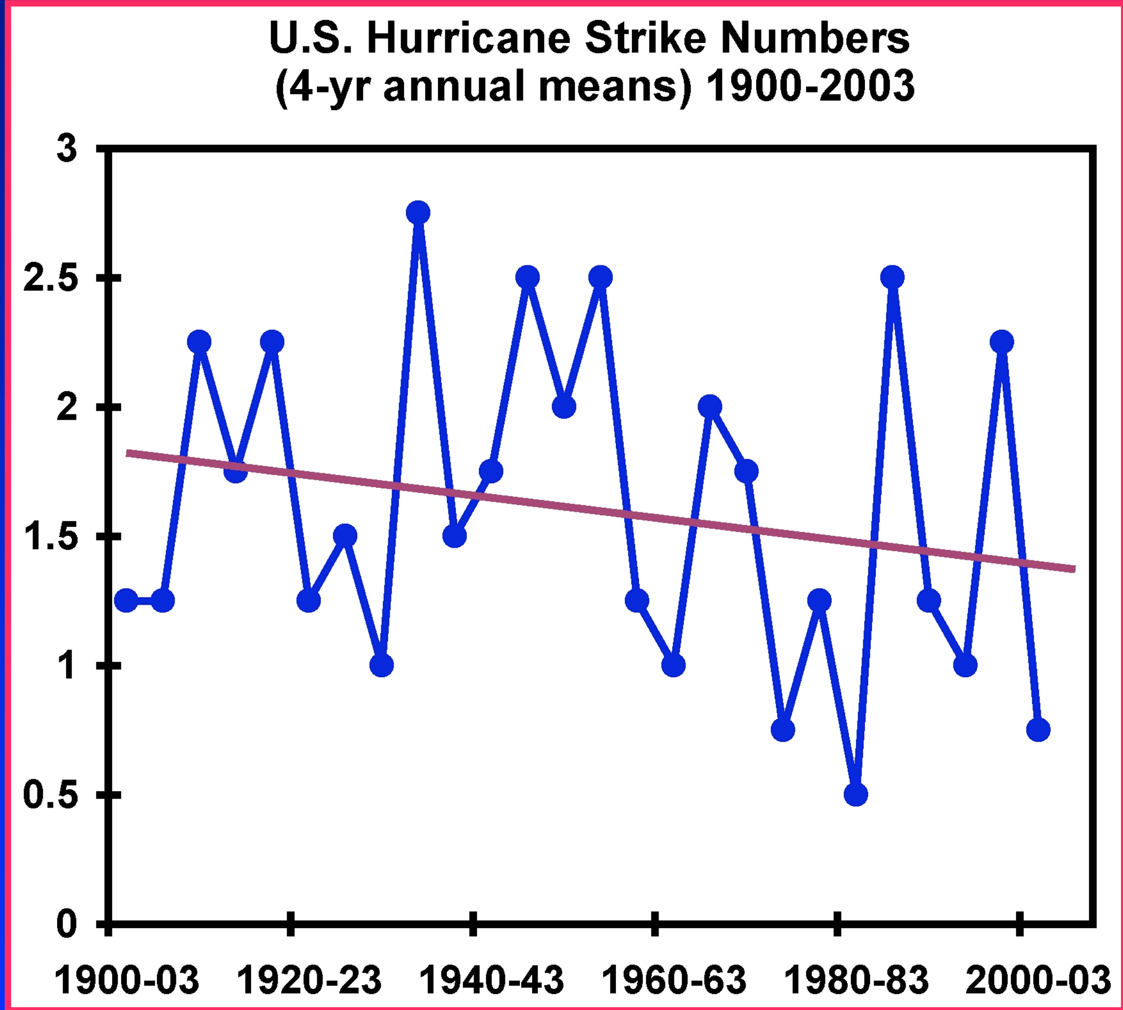
2. However, the increase in the number of hurricanes and in hurricane maximum intensity over the next 100 years is thought to be about 10% and thus is small compared to the range of natural year-to-year variability.

4. Lessons Learned and Future Risks for Florida

2004 In Proper Context

The historical record shows repeated quiet and active periods for U.S. hurricanes.

For the prior 4-year period 2000-2003 U.S. hurricane strikes were **50% below average** and U.S. hurricane insured losses were **80% below norm.**



2004 has seen the recent hurricane 'dry spell' corrected.

Lessons Learnt From 2004

1. Perception that US hurricane landfalls ‘hardly ever happen’ has been corrected.

2. Recognition that the probability of multiple event seasons needs consideration when analysing US hurricane risk.

3. More notice should be taken of forecasts (short-range and seasonal). Their increasing skill (witness 2004) offers business benefit and opportunity.

Outlook For 2005 Season

Two long-range hurricane outlooks exist for 2005: Gray and TSR.

Gray predicts activity will be 115% of average while TSR predicts activity will be 155% of average.

The TSR prediction includes:

- A 67% probability of above-normal U.S. landfalling hurricane activity, a 22% likelihood of a near-normal season and only a 11% chance of a below-normal season.

Taken together the Gray and TSR hurricane outlooks point to 2005 being another active hurricane season (albeit less active than 2004).

Future Risk to (Re)Insurers?

Although uncertainties remain, the vast majority of future hurricane losses in Florida, the U.S. and the Caribbean are thought to continue to result from natural interannual and decadal climate variability and not from global warming.

Since traditional insurance policies are set for the year ahead (or at most out to five years) the impact of global warming on risk over this timescale will be small or negligible.