

# HURRICANE AND TYPHOON FORECASTING: THE OUTLOOK FOR 2003

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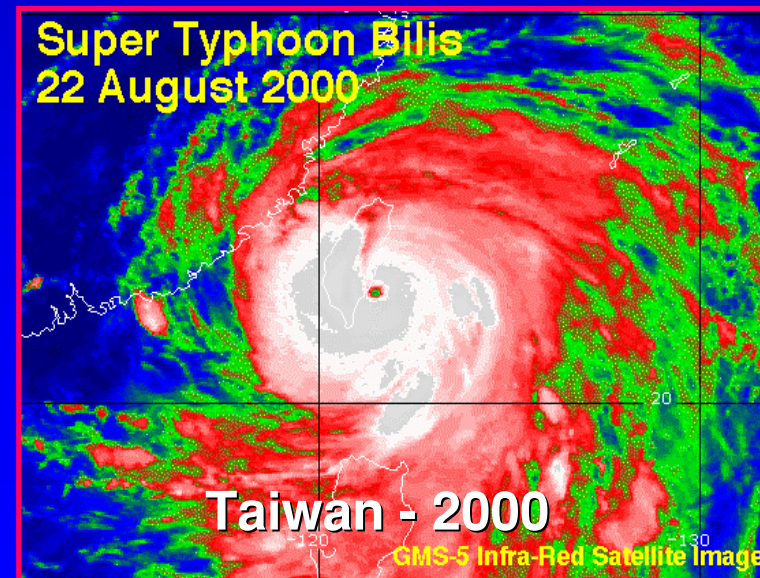
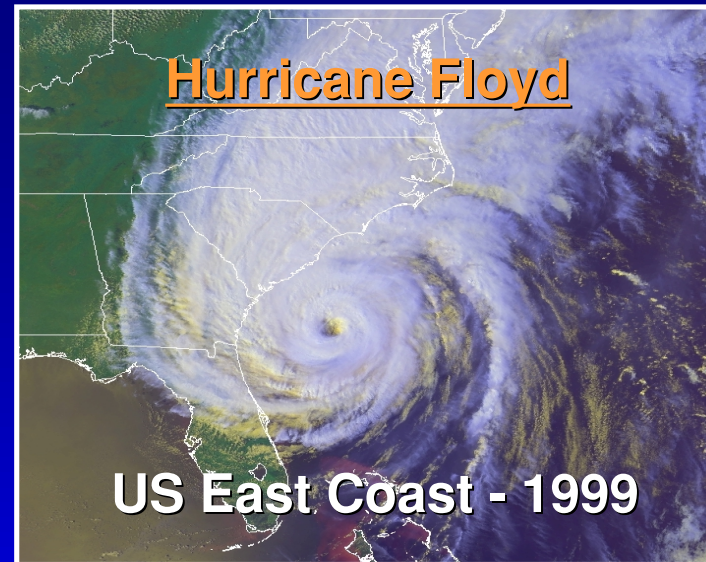
**London Claims Seminar  
The Old Library, Lloyd's of London  
14th May 2003**





# Tropical Cyclone Impacts

- **USA.** Hurricane annual damage bill 1925-2002 is estimated as US \$ 5.3Bn (at 2002 \$).
- **Asia.** Typhoon annual damage bill (1990-2001) is US \$3.3Bn. (at 2002 \$).
- **Asia.** Typhoon annual fatality rate is 700 deaths (1990-2001).





# Seasonal Forecast Relevance (1)

- **Substantial interannual variability exists in regional tropical cyclone losses.** For example, in the US in 1999 and 1997, the losses were US \$ 8.2 bn and just US \$ 0.16 bn respectively.
- Insurers and reinsurers have long recognised that skillful long-range forecasts of seasonal US and Caribbean hurricane strike numbers could be used to optimise the prior season purchase of reinsurance and retrocession, thereby **reducing risk and volatility.....**



## Seasonal Forecast Relevance (2)

- However, three facts have taken the edge of the use of seasonal hurricane forecasts in (re)insurance business decisions to date:
  1. **Hurricane Andrew** (1992) occurred in a relatively inactive hurricane season.
  2. A general **lack of confidence concerning the accuracy** of seasonal hurricane forecasts.
  3. The **short record of insurance industry loss data** (from ~1990) makes a reliable assessment of forecast value difficult.



# **1. Available Forecasts and Recent Performance**

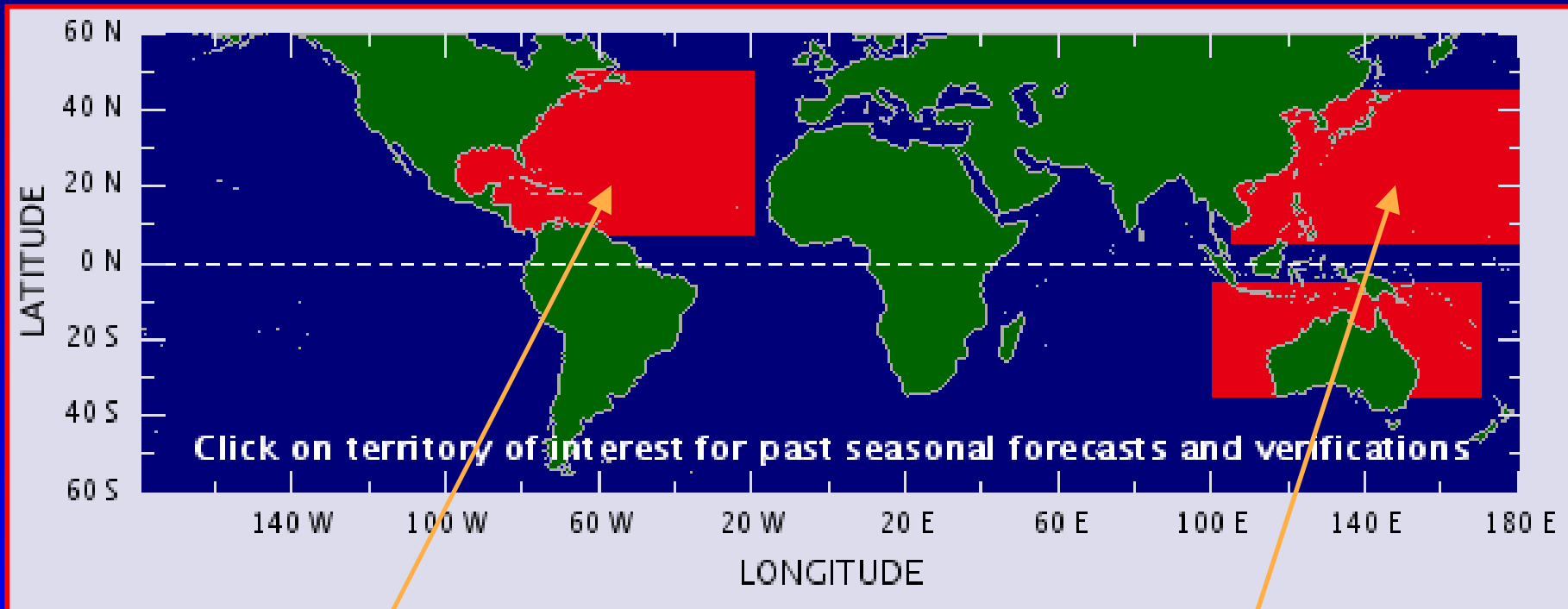


# History

- Seasonal forecasts of Atlantic basin hurricane activity were pioneered by **William Gray at Colorado State University in 1984**. Indeed Gray's forecasts are arguably the first seasonal forecast of any climate phenomenon.
- Today seasonal forecasts of tropical cyclone activity are available for a **number of ocean basins and different landfalling areas**. These forecasts are issued by a range of agencies and university groups.



# Forecast Regions



**Colorado State University  
Tropical Storm Risk (TSR)  
NOAA  
Meteorol. Institute, Cuba**

**University of Hong Kong  
Tropical Storm Risk (TSR)**



# The TSR Venture

- Founded in 2000, **Tropical Storm Risk (TSR)** offers a sound and independent resource for forecasting the risk from tropical storms worldwide.
- The venture provides innovative forecast products to increase risk awareness and to help decision making within the (re)insurance industry, other business sectors, government and society.
- The **TSR consortium** comprises experts on insurance, risk management and seasonal climate forecasting.

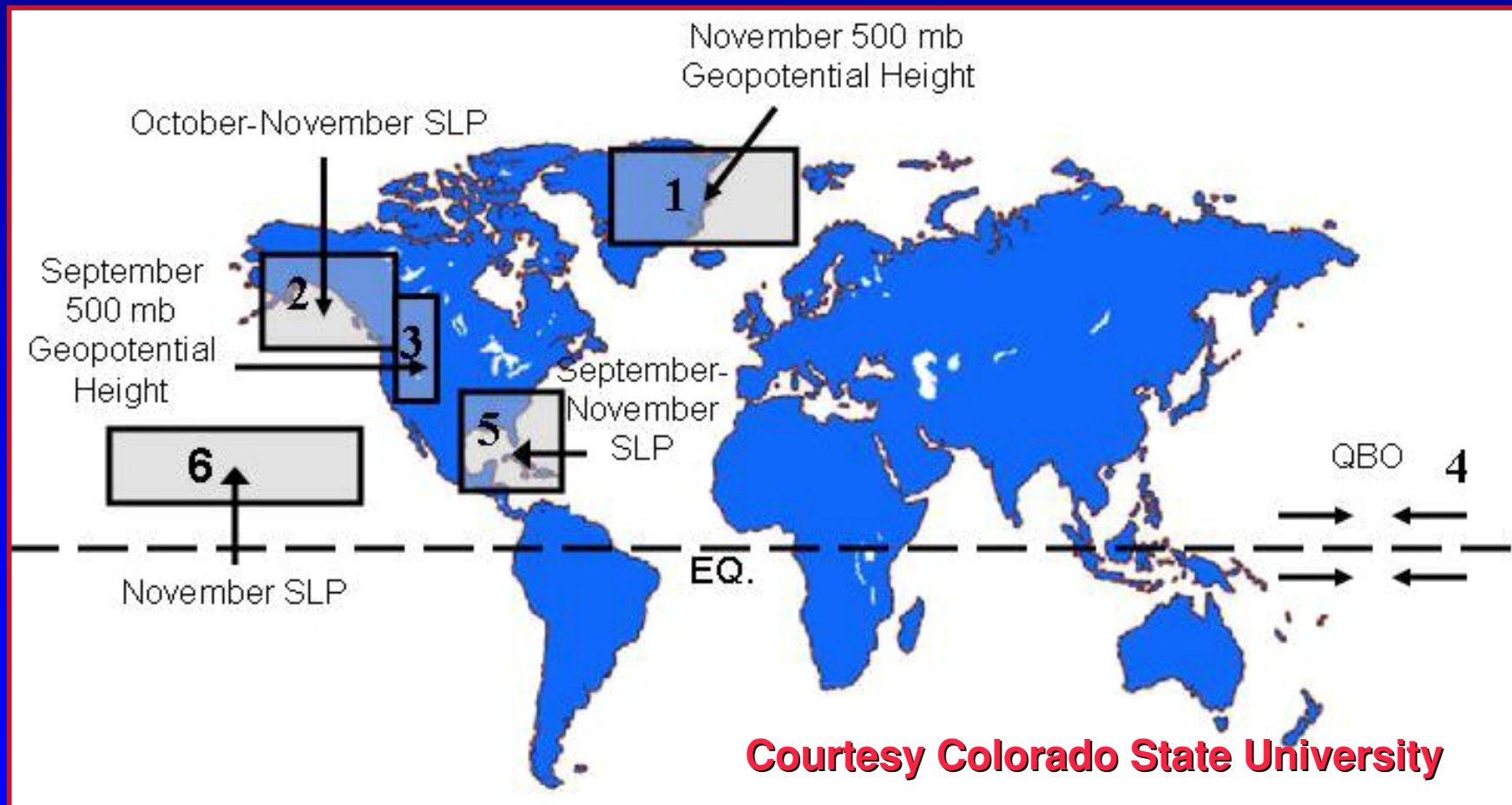






# Gray Forecast Methodology

New extended range predictors for 2003





# TSR Forecast Methodology

## Statistical Model and Strategy

- Interannual variability in hurricane numbers modelled using a Gaussian model.
- Divide Atlantic basin into three sub-regions:
  - Main development region (10°N-20°N, 20°W-60°W)
  - Caribbean Sea and Gulf of Mexico
  - Extra-tropical north Atlantic.

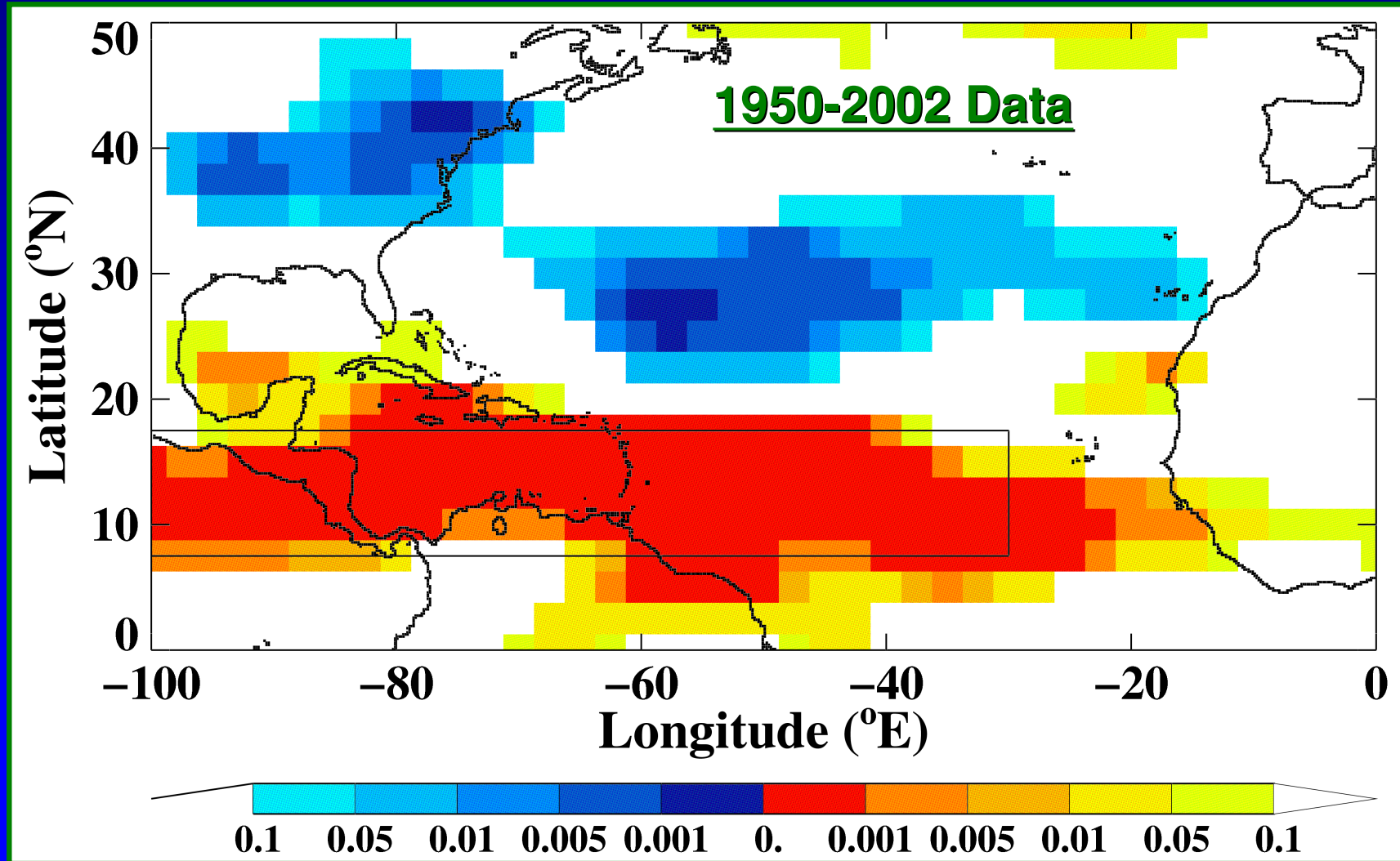
## Predictors Used

1. JUL-AUG-SEP (JAS) forecast 925mb U-wind for 7.5°N-17.5°N, 30°W-100°W.
2. AUG-SEP (AS) forecast SST for Atlantic hurricane main development region 10°N-20°N, 20°W-60°W.



# Atlantic Hurricane Predictor 1

JAS 925 mb Trade Wind Speed (7.5-17.5°N, 30-100°W)









# Atlantic Forecast Performance 2002

Atlantic Total Numbers 2002				
		Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number ( $\pm$ SD) (1992-2001)		11.5 ( $\pm$ 4.1)	6.9 ( $\pm$ 2.9)	2.9 ( $\pm$ 2.0)
Average Number ( $\pm$ SD) (1972-2001)		9.5 ( $\pm$ 3.6)	5.7 ( $\pm$ 2.4)	2.1 ( $\pm$ 1.5)
Actual Number 2002		12	4	2
TSR Forecasts( $\pm$ SD)	07 Aug 2002	8.1 ( $\pm$ 2.2)	3.9 ( $\pm$ 1.3)	1.3 ( $\pm$ 1.4)
	08 July 2002	6.8 ( $\pm$ 2.3)	3.1 ( $\pm$ 1.5)	0.9 ( $\pm$ 1.6)
	07 June 2002	7.5 ( $\pm$ 2.1)	3.6 ( $\pm$ 1.6)	1.1 ( $\pm$ 1.4)
	07 May 2002	8.9 ( $\pm$ 2.7)	4.6 ( $\pm$ 1.9)	1.6 ( $\pm$ 1.5)
	05 Apr 2002	11.2 ( $\pm$ 3.1)	6.3 ( $\pm$ 2.3)	2.4 ( $\pm$ 1.9)
	06 Mar 2002	12.5 ( $\pm$ 3.6)	7.2 ( $\pm$ 2.5)	2.8 ( $\pm$ 1.9)
	06 Feb 2002	13.6 ( $\pm$ 3.5)	8.0 ( $\pm$ 2.5)	3.2 ( $\pm$ 1.8)
	10 Jan 2002	13.1 ( $\pm$ 3.6)	7.7 ( $\pm$ 2.6)	3.0 ( $\pm$ 1.8)
Gray/Colorado State-University Forecasts	03 Dec 2001	13.0 ( $\pm$ 3.6)	7.5 ( $\pm$ 2.5)	3.0 ( $\pm$ 1.6)
	02 Sep 2002	8	3	1
	07 Aug 2002	9	4	1
	31 May 2002	11	6	2
	05 Apr 2002	12	7	3
NOAA Forecasts	07 Dec 2001	13	8	4
	08 Aug 2002	7-10	4-6	1-3
Meteorological Institute, Cuba Forecasts	20 May 2002	9-13	6-8	2-3
	01 Aug 2002	12	9	-
	02 May 2002	12	9	-



# TSR/Gray Skill Comparison

Strength	Lead	Start Year	End Year	PVE		RMSE <sub>CL</sub> (%)		MAE <sub>CL</sub> (%)	
				TSR	Gray	TSR	Gray	TSR	Gray
H	0	1987	2001	67	45	43	25	43	22
H	2	1987	2001	44	22	21	13	17	14
H	4	1995	2001	30	0	20	10	19	12
H	8	1992	2001	23	0	17	0	15	0

- **TSR outperforms Gray at all leads.**
- **However, one can not conclude the TSR model is better than the Gray model since the latter has changed with time.**



# NOAA ACE Index Forecasts

- The NOAA Accumulated Cyclone Energy (ACE) Index is the sum of the squares of maximum 1-min sustained winds every 6 hours for all systems while they are at least tropical storm strength.
- Since this index reflects a combination of intensity and duration it should be a **better measure of likely damage** than the number of tropical storms or hurricanes alone.



# Skill Score and Uncertainty

- 1 Employ the percentage improvement in mean square error (MSE) over a running prior 10-year climatological forecast:

$$\text{MSE}_{\text{Clim}} (\%) = (1 - \text{MSE}_{\text{Fore}} / \text{MSE}_{\text{Clim}}) \times 100$$

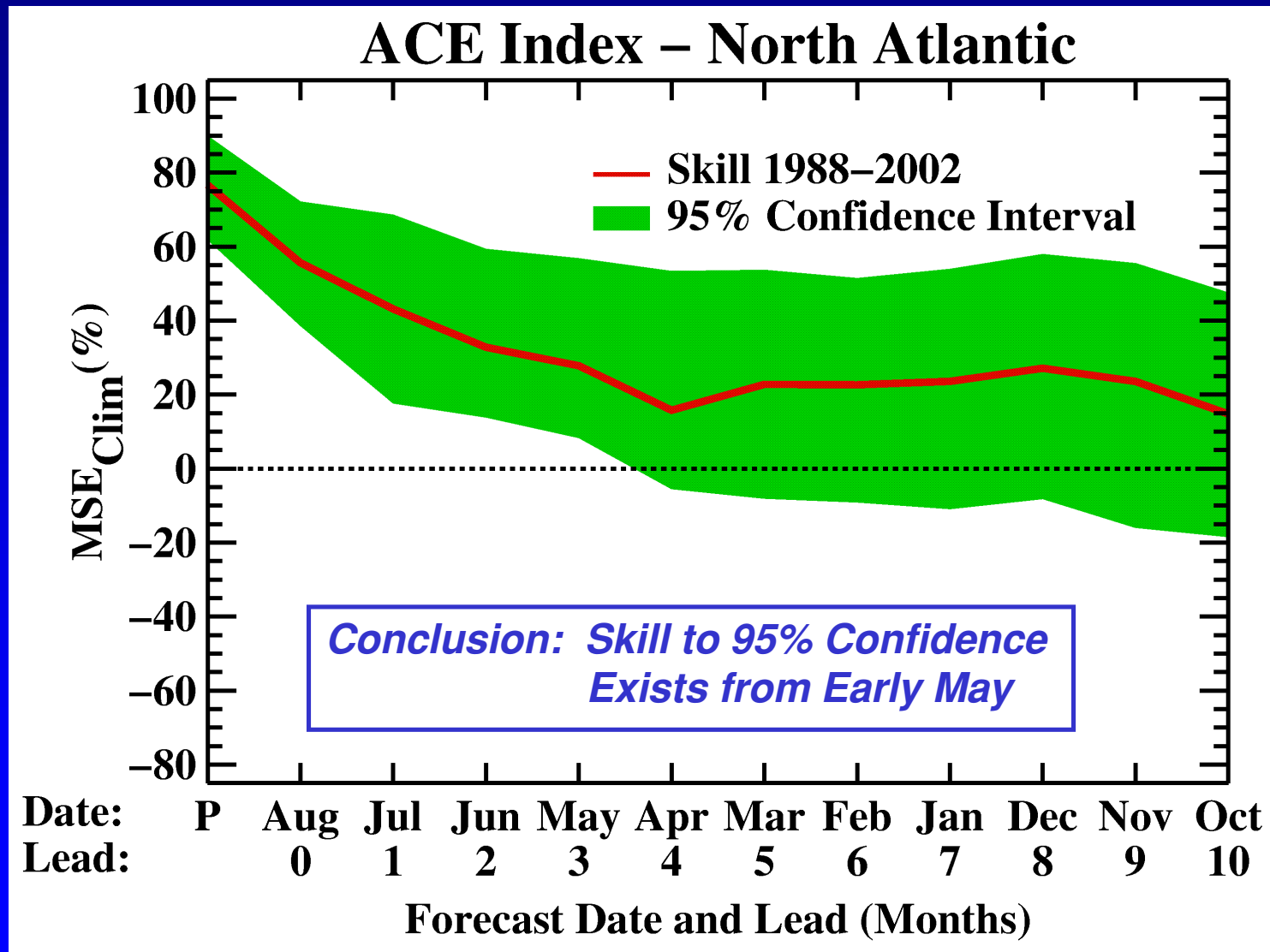
*This is the standard skill score recommended by the World Meteorological Organisation (2002) for seasonal forecast skill assessment.*

- 1 Employ the **standard bootstrap method** with replacement to compute the 95% confidence interval on skill.



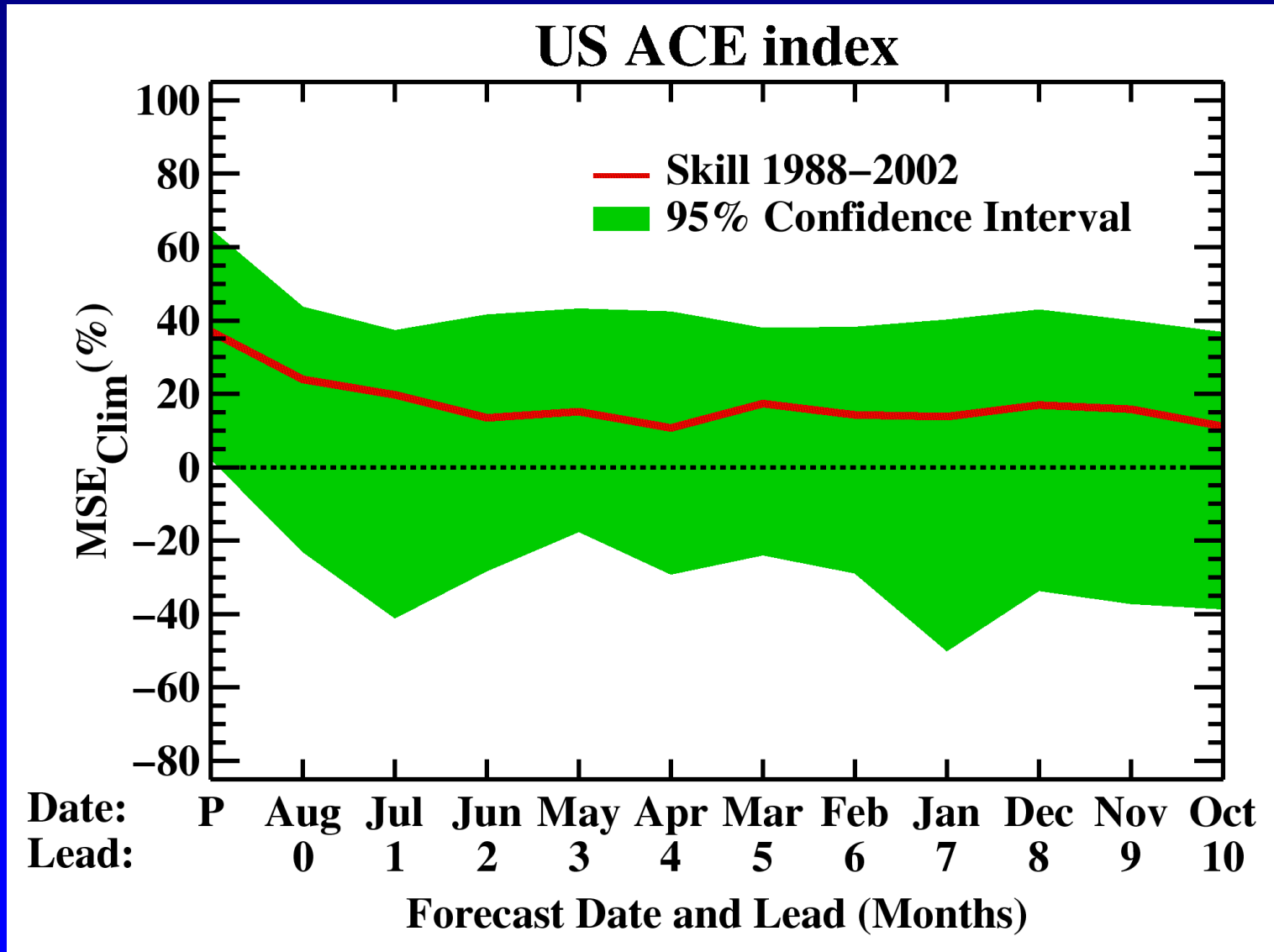


# TSR Hindcast Skill for Atlantic Seasonal ACE Index





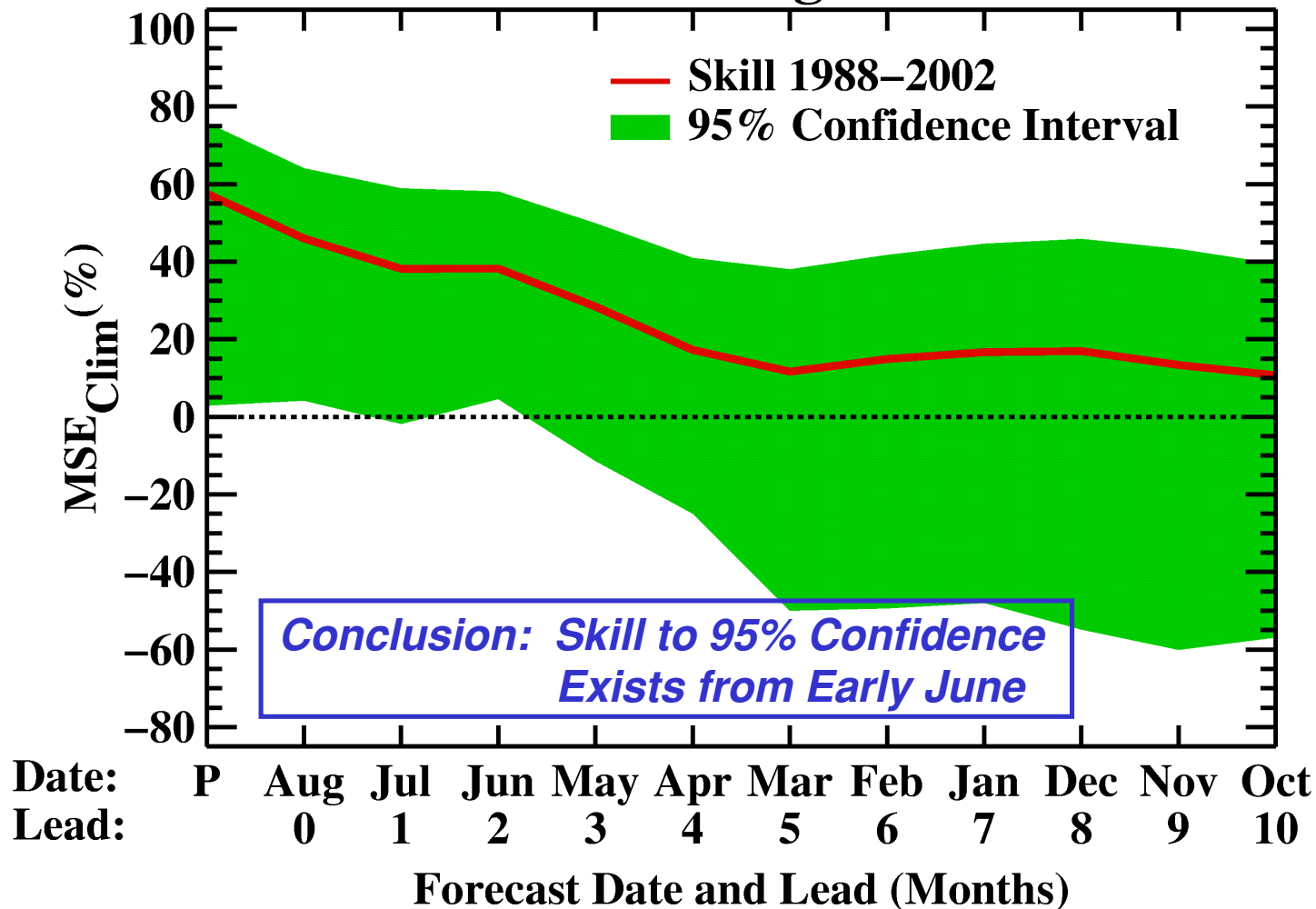
# TSR Hindcast Skill for Seasonal US ACE Index





# TSR Hindcast Skill for Seasonal Hurricane Strikes on the LA

## Lesser Antilles Landfalling Hurricane Numbers





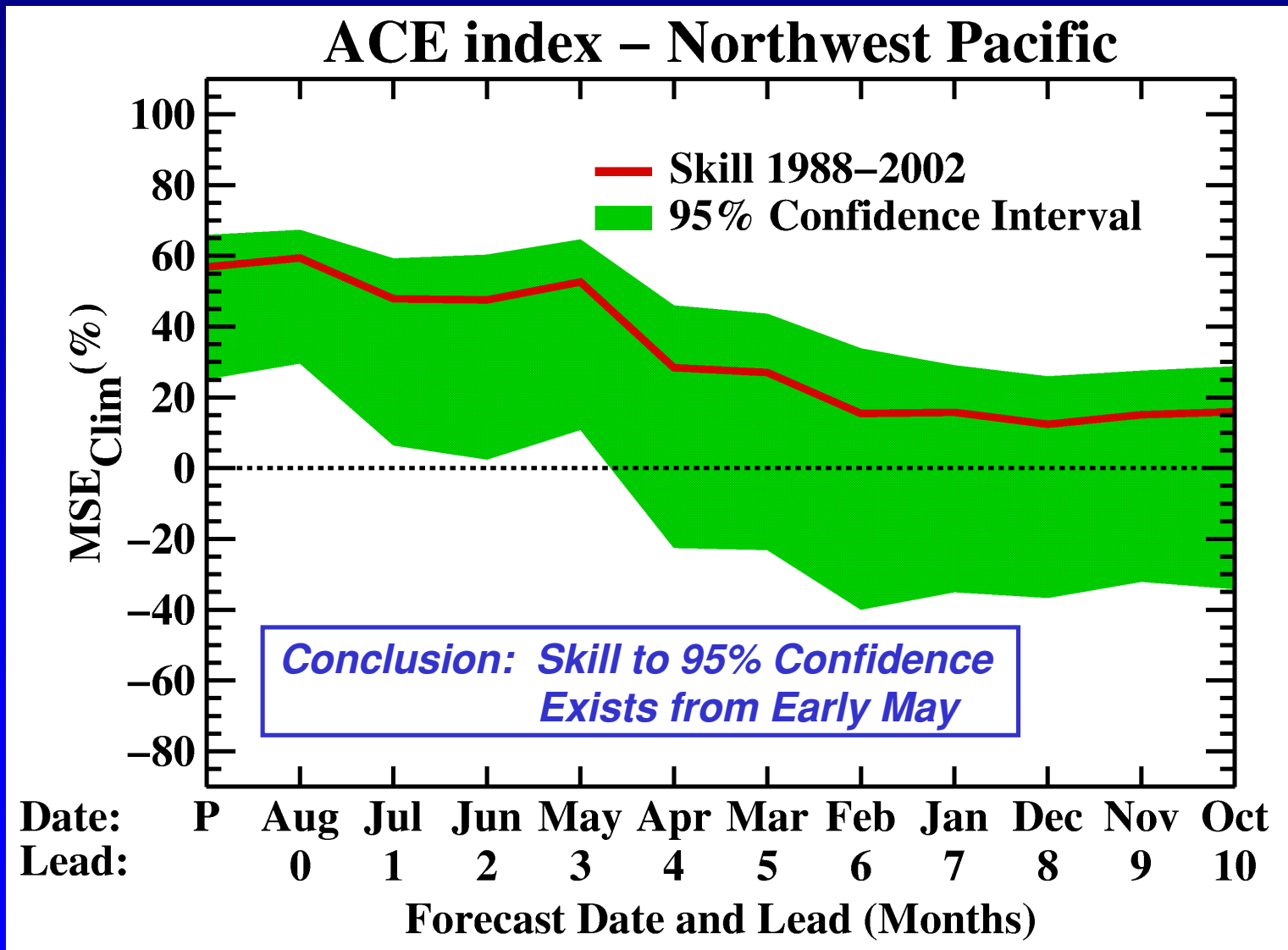
# NW Pacific Forecast Performance 2002

## NW Pacific Total Numbers and ACE Index in 2002

		ACE Index ( $\times 10^4$ knots <sup>2</sup> )	Tropical Storms	Typhoons	Intense Typhoons
Average Number ( $\pm$ SD) (1992-2001)		319 ( $\pm$ 140)	27.4 ( $\pm$ 4.6)	16.9 ( $\pm$ 4.3)	9.0 ( $\pm$ 3.1)
Average Number ( $\pm$ SD) (1972-2001)		289 ( $\pm$ 106)	26.3 ( $\pm$ 4.0)	16.4 ( $\pm$ 3.6)	8.2 ( $\pm$ 3.3)
Actual Number 2002		388	26	17	12
TSR Forecast ( $\pm$ FE)	6 August 2002	-	28.4 ( $\pm$ 4.2)	19.0 ( $\pm$ 3.4)	11.5 ( $\pm$ 1.7)
	11 July 2002	-	28.6 ( $\pm$ 4.4)	19.2 ( $\pm$ 3.7)	11.8 ( $\pm$ 2.2)
	7 June 2002	-	30.8 ( $\pm$ 4.5)	21.1 ( $\pm$ 3.5)	10.5 ( $\pm$ 2.2)
	7 May 2002	-	30.5 ( $\pm$ 4.6)	20.9 ( $\pm$ 3.4)	10.3 ( $\pm$ 2.2)
	5 Apr 2002	-	29.6 ( $\pm$ 5.0)	19.8 ( $\pm$ 4.1)	9.8 ( $\pm$ 2.6)
	6 Mar 2002	-	28.6 ( $\pm$ 4.8)	18.7 ( $\pm$ 4.1)	9.3 ( $\pm$ 2.5)
Chan Forecast ( $\pm$ SD)	28 June 2002	-	27 ( $\pm$ 3)	18 ( $\pm$ 2)	-
	7 May 2002	-	27 ( $\pm$ 3)	17 ( $\pm$ 2)	-



# TSR Hindcast Skill for NW Pacific Seasonal ACE Index





## **2. Current Outlooks for 2003**



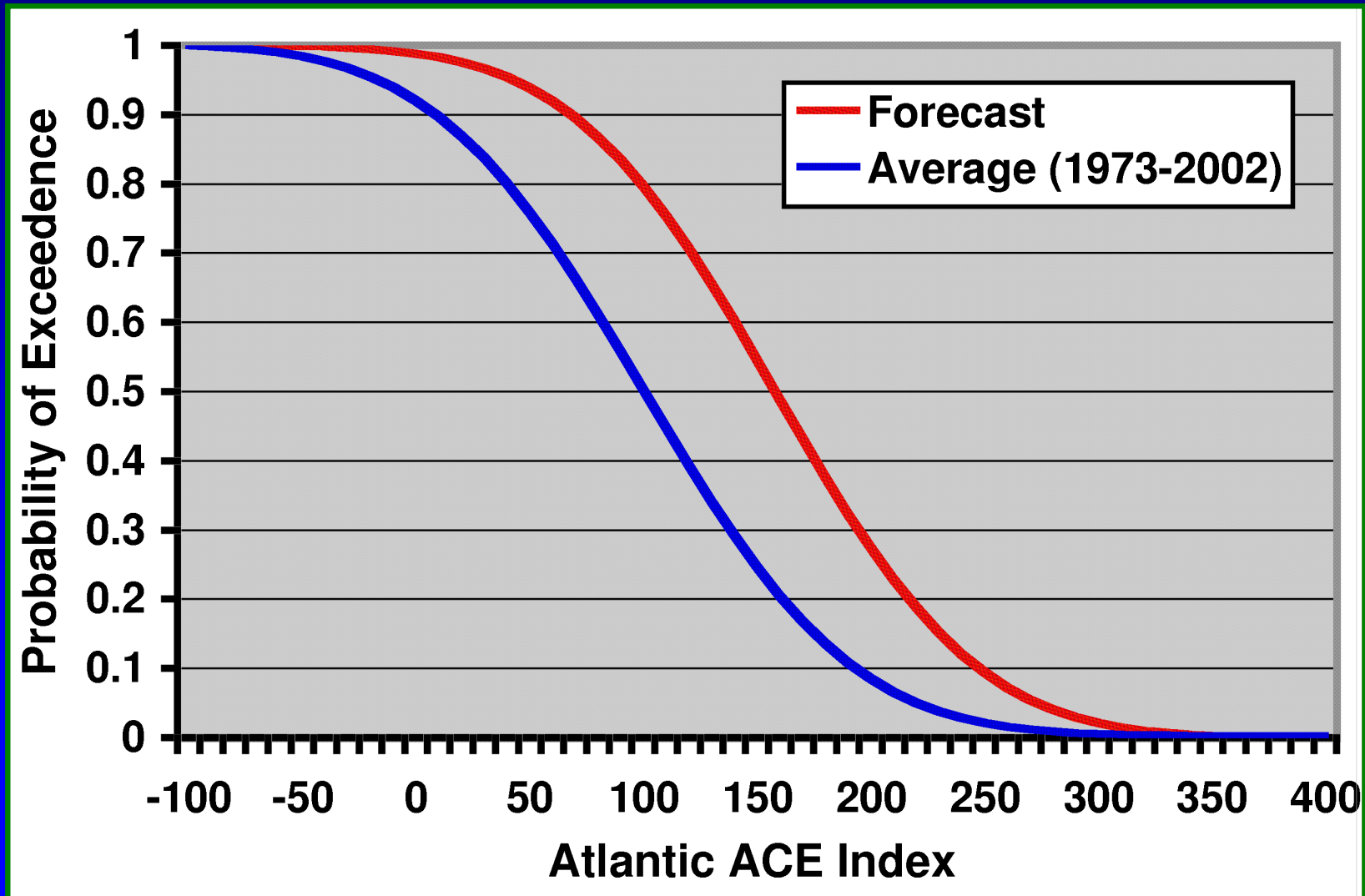
# Atlantic Outlook 2003

## Atlantic ACE Index and System Numbers 2003

		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number ( $\pm$ SD) (1993-2002)		153 ( $\pm$ 94)	12.1 ( $\pm$ 3.6)	6.9 ( $\pm$ 2.9)	3.0 ( $\pm$ 1.9)
Average Number ( $\pm$ SD) (1973-2002)		100 ( $\pm$ 72)	9.8 ( $\pm$ 3.4)	5.7 ( $\pm$ 2.4)	2.1 ( $\pm$ 1.4)
TSR Forecasts ( $\pm$ FE)	6 May 2003	158 ( $\pm$ 70)	12.4 ( $\pm$ 2.7)	7.0 ( $\pm$ 2.0)	2.8 ( $\pm$ 1.5)
	11 Apr 2003	128 ( $\pm$ 85)	11.1 ( $\pm$ 2.9)	6.1 ( $\pm$ 2.4)	2.4 ( $\pm$ 1.8)
	5 Mar 2003	166 ( $\pm$ 87)	12.7 ( $\pm$ 3.5)	7.1 ( $\pm$ 2.7)	2.9 ( $\pm$ 1.9)
	5 Feb 2003	180 ( $\pm$ 90)	13.3 ( $\pm$ 3.3)	7.6 ( $\pm$ 2.7)	3.1 ( $\pm$ 1.8)
	7 Jan 2003	156 ( $\pm$ 90)	12.3 ( $\pm$ 3.4)	6.9 ( $\pm$ 2.8)	2.7 ( $\pm$ 1.8)
	16 Dec 2002	-	12.4 ( $\pm$ 3.5)	7.0 ( $\pm$ 2.8)	2.8 ( $\pm$ 1.8)
Gray Forecasts	4 Apr 2003		12	8	3
	6 Dec 2002		12	8	3
Meteorological Institute, Cuba Forecast	2 May 2003	-	10	6	-



# Probability of Exceedance Forecast for Atlantic ACE Index







# US Landfalling Outlook 2003

## US Landfalling ACE Index and Numbers 2003

		ACE Index	Named Tropical Storms	Hurricanes
Average Number ( $\pm$ SD) (1993-2002)		4.5 ( $\pm$ 4.6)	3.8 ( $\pm$ 2.1)	1.2 ( $\pm$ 1.2)
Average Number ( $\pm$ SD) (1973-2002)		2.6 ( $\pm$ 3.4)	2.8 ( $\pm$ 2.0)	1.2 ( $\pm$ 1.3)
TSR Forecasts ( $\pm$ FE)	6 May 2003	4.6 ( $\pm$ 4.3)	3.6 ( $\pm$ 1.9)	1.7 ( $\pm$ 1.0)
	11 Apr 2003	3.6 ( $\pm$ 4.6)	3.2 ( $\pm$ 1.9)	1.4 ( $\pm$ 1.1)
	5 Mar 2003	4.8 ( $\pm$ 4.5)	3.7 ( $\pm$ 1.9)	1.7 ( $\pm$ 1.1)
	5 Feb 2003	5.2 ( $\pm$ 4.6)	3.9 ( $\pm$ 1.9)	1.8 ( $\pm$ 1.1)
	7 Jan 2003	-	3.6 ( $\pm$ 1.9)	1.6 ( $\pm$ 1.1)
	16 Dec 2002	-	3.6 ( $\pm$ 1.9)	1.7 ( $\pm$ 1.1)



# Lesser Antilles Landfalling Outlook 2003

## Lesser Antilles Landfalling Numbers 2003

		Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number ( $\pm$ SD) (1993-2002)		1.6 ( $\pm$ 0.8)	0.7 ( $\pm$ 0.8)	0.3 ( $\pm$ 0.5)
Average Number ( $\pm$ SD) (1973-2002)		1.1 ( $\pm$ 1.0)	0.4 ( $\pm$ 0.6)	0.2 ( $\pm$ 0.4)
TSR Forecasts ( $\pm$ FE)	6 May 2003	1.6 ( $\pm$ 0.9)	0.7 ( $\pm$ 0.7)	0.4 ( $\pm$ 0.4)
	11 Apr 2003	1.4 ( $\pm$ 1.0)	0.6 ( $\pm$ 0.7)	0.3 ( $\pm$ 0.4)
	5 Mar 2003	1.7 ( $\pm$ 1.0)	0.7 ( $\pm$ 0.8)	0.4 ( $\pm$ 0.4)
	5 Feb 2003	1.8 ( $\pm$ 1.0)	0.8 ( $\pm$ 0.8)	0.4 ( $\pm$ 0.4)
	7 Jan 2003	1.6 ( $\pm$ 1.0)	0.7 ( $\pm$ 0.8)	0.4 ( $\pm$ 0.4)
	16 Dec 2002	1.7 ( $\pm$ 0.8)	0.7 ( $\pm$ 0.7)	0.4 ( $\pm$ 0.4)



# NW Pacific Outlook 2003

## NW Pacific ACE Index and System Numbers 2003

		ACE Index	Tropical Storms	Typhoons	Intense Typhoons
Average Number ( $\pm$ SD) (1993-2002)		300 ( $\pm$ 113)	27.8 ( $\pm$ 5.0)	17.2 ( $\pm$ 4.7)	9.1 ( $\pm$ 3.2)
Average Number ( $\pm$ SD) (1973-2002)		285 ( $\pm$ 97)	26.7 ( $\pm$ 4.3)	16.6 ( $\pm$ 3.7)	8.0 ( $\pm$ 3.0)
TSR Forecasts ( $\pm$ FE)	6th May 2003	284 ( $\pm$ 84)	26.0 ( $\pm$ 4.9)	16.3 ( $\pm$ 4.1)	8.2 ( $\pm$ 2.3)
	11th April 2003	318 ( $\pm$ 102)	26.7 ( $\pm$ 5.1)	17.1 ( $\pm$ 4.5)	9.2 ( $\pm$ 2.9)
	5th March 2003	297 ( $\pm$ 100)	26.2 ( $\pm$ 5.1)	16.6 ( $\pm$ 4.5)	8.5 ( $\pm$ 2.9)
Chan Forecast ( $\pm$ SD)	24th April 2003	-	26 ( $\pm$ 3)	16 ( $\pm$ 2)	-



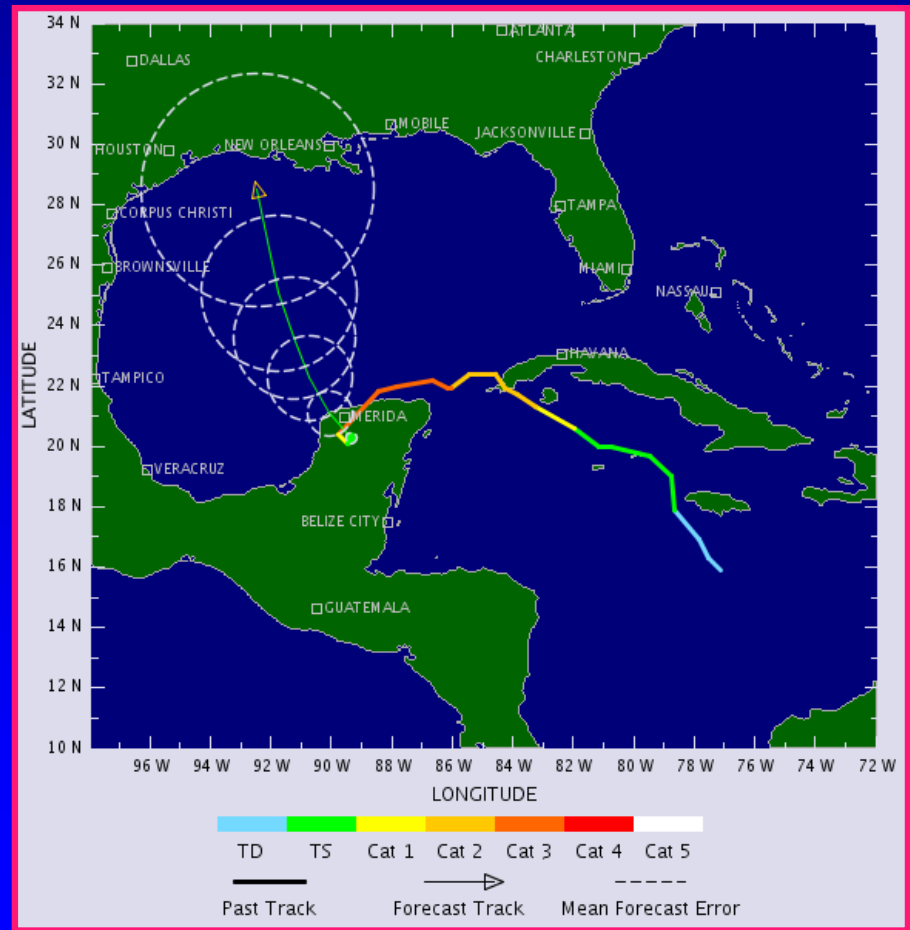
# 3. Future Developments



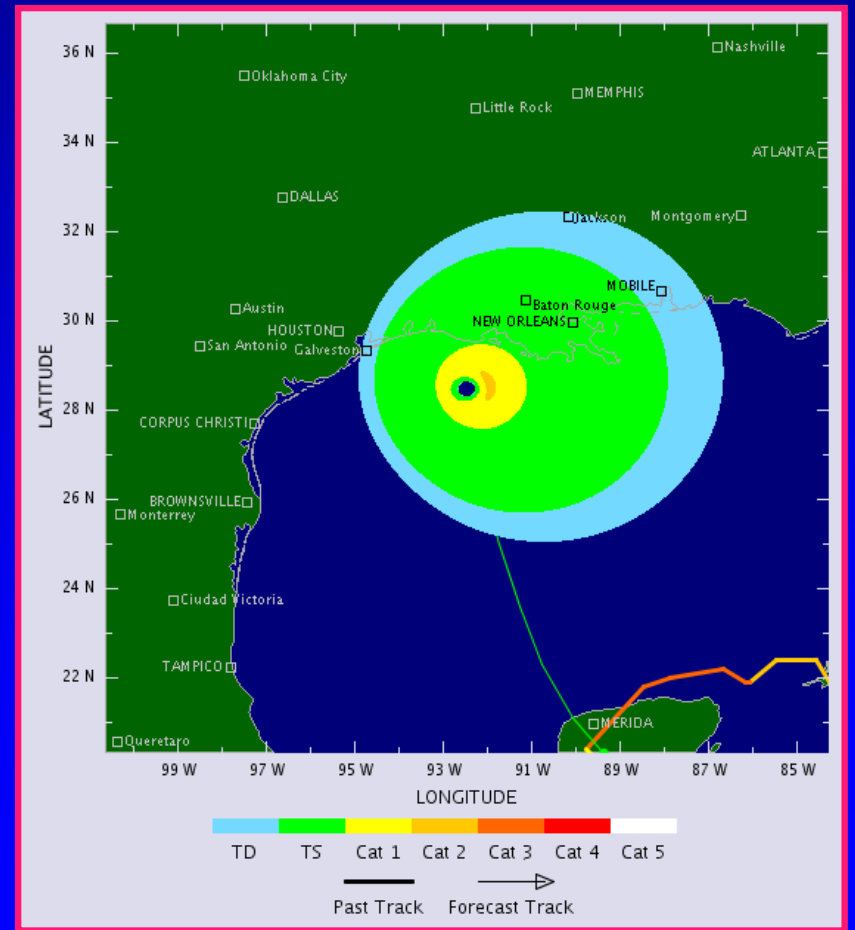
# TSR Tropical Storm Tracker

23rd September 2002, 12:00 GMT

**Forecast Track and Error  
Out to 72 Hours Lead**

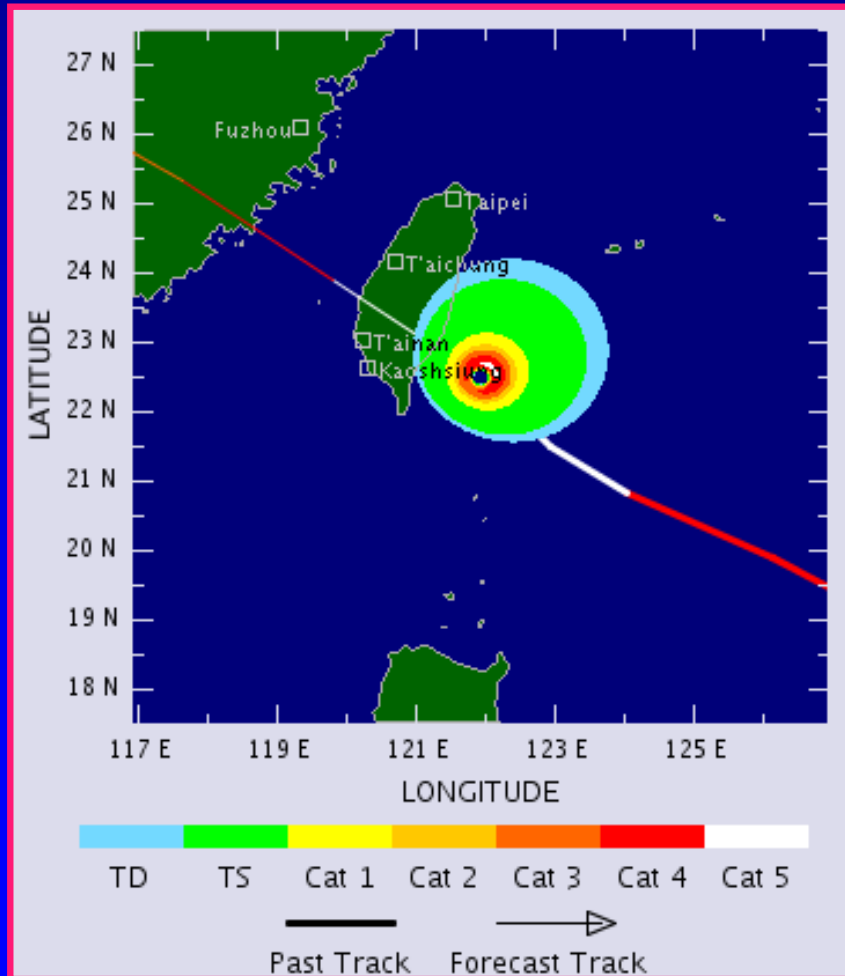


**Forecast Windfield  
72 Hours Lead**

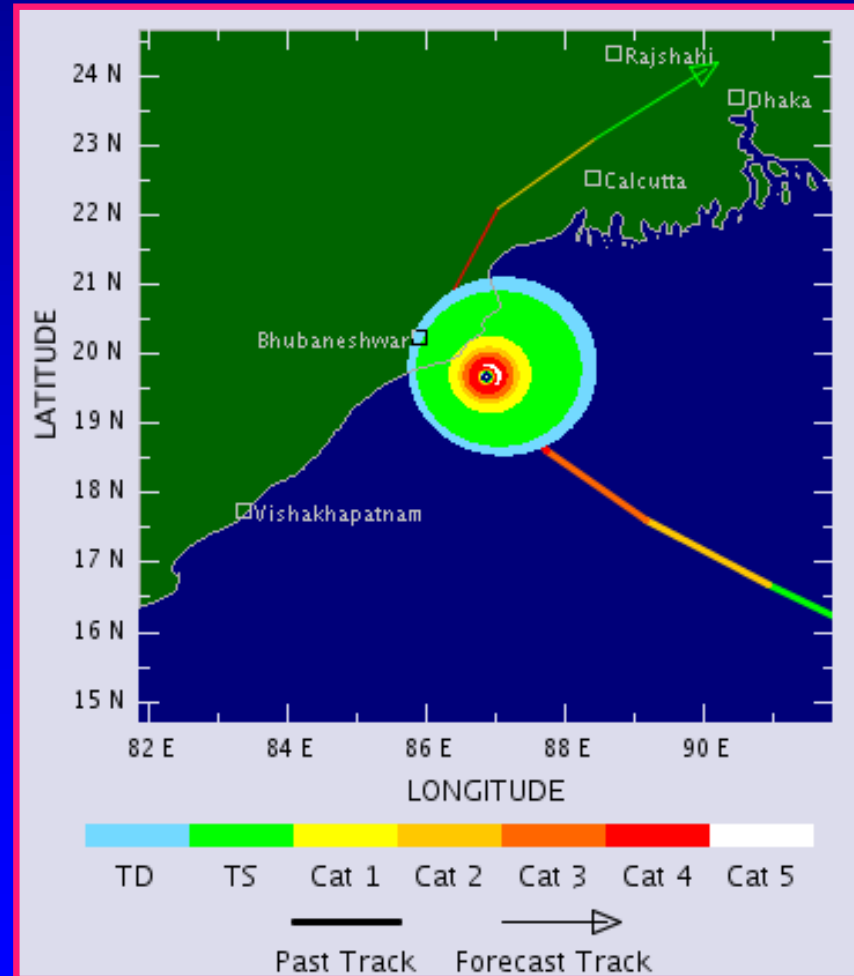


# Historical Storms

***Super Typhoon Bilis  
Taiwan, 22nd August, 2000***



***Cyclone 05B, Orissa  
India, 29th October 1999***





# Business Application

- The TSR correlation skill for predicting the **US ACE Index** in true independent hindcast mode for the 30-year period 1973-2002 is **0.48**.
- In collaboration with the Helvetia Patria Group we are developing a method to simulate 10,000 years of US hurricane landfalls, losses and ACE index forecasts to **examine the business relevance of the forecasted US ACE skills** for reinsurance/retrocession buy and sell strategies.
- Results show that a **Forecast Strategy** - which uses the TSR ACE Index forecasts to decide whether to buy - outperforms traditional buying strategies by about **10%** in terms of protection purchase efficiency.



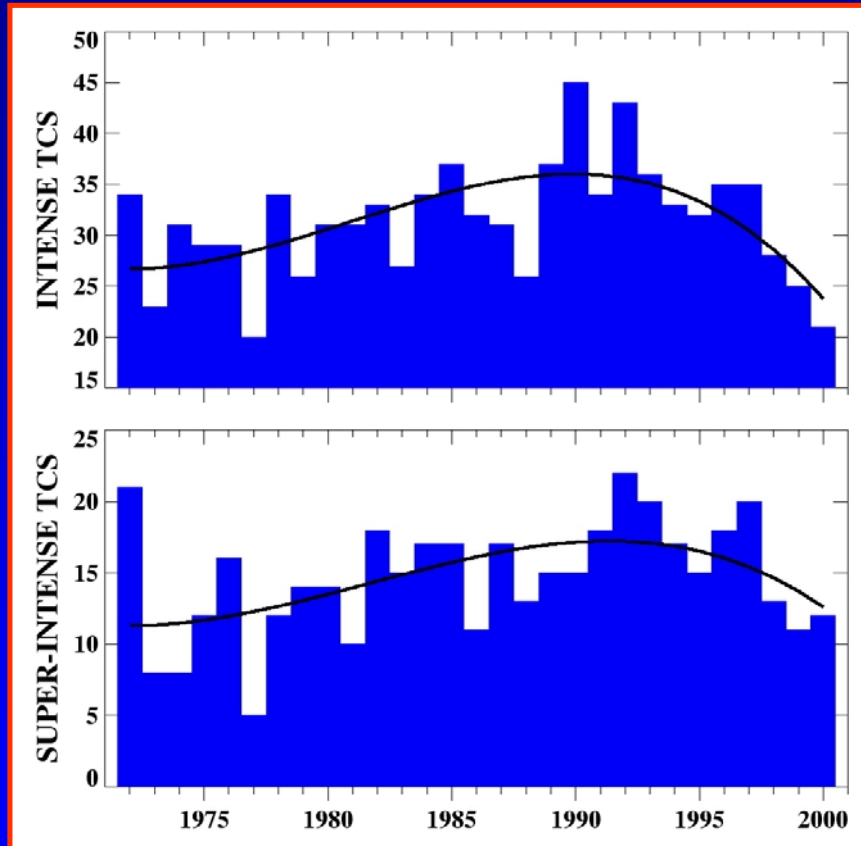
# **4. Hurricanes and Global Warming**



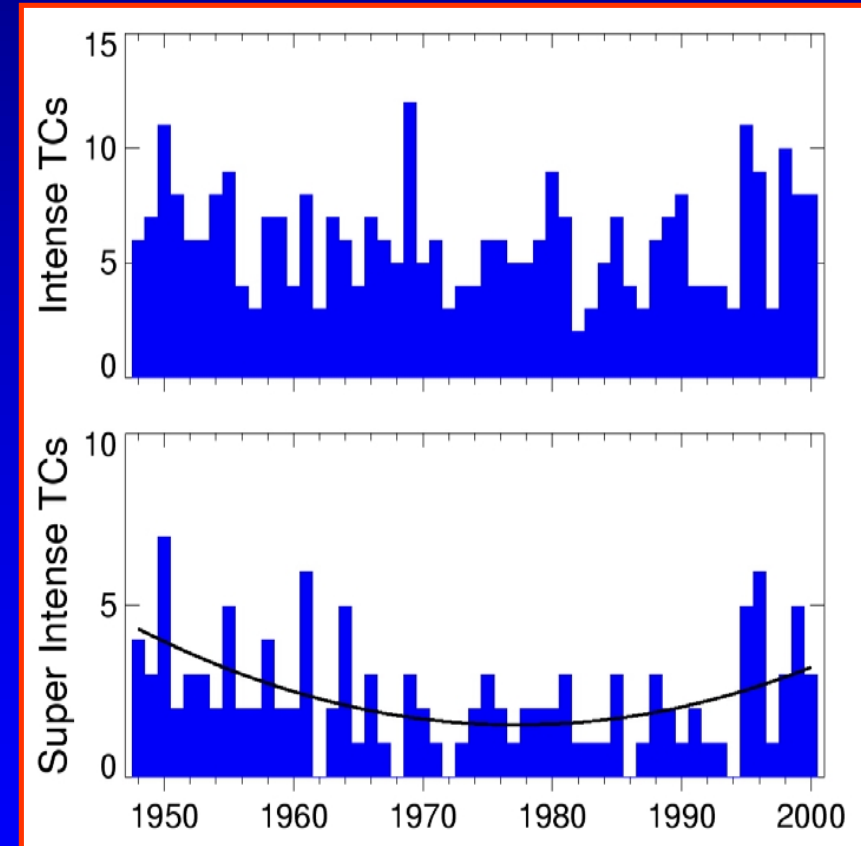


# Trends in Intense Tropical Cyclone Numbers

Northern Hemisphere 1971-2000



Atlantic Basin 1948-2000

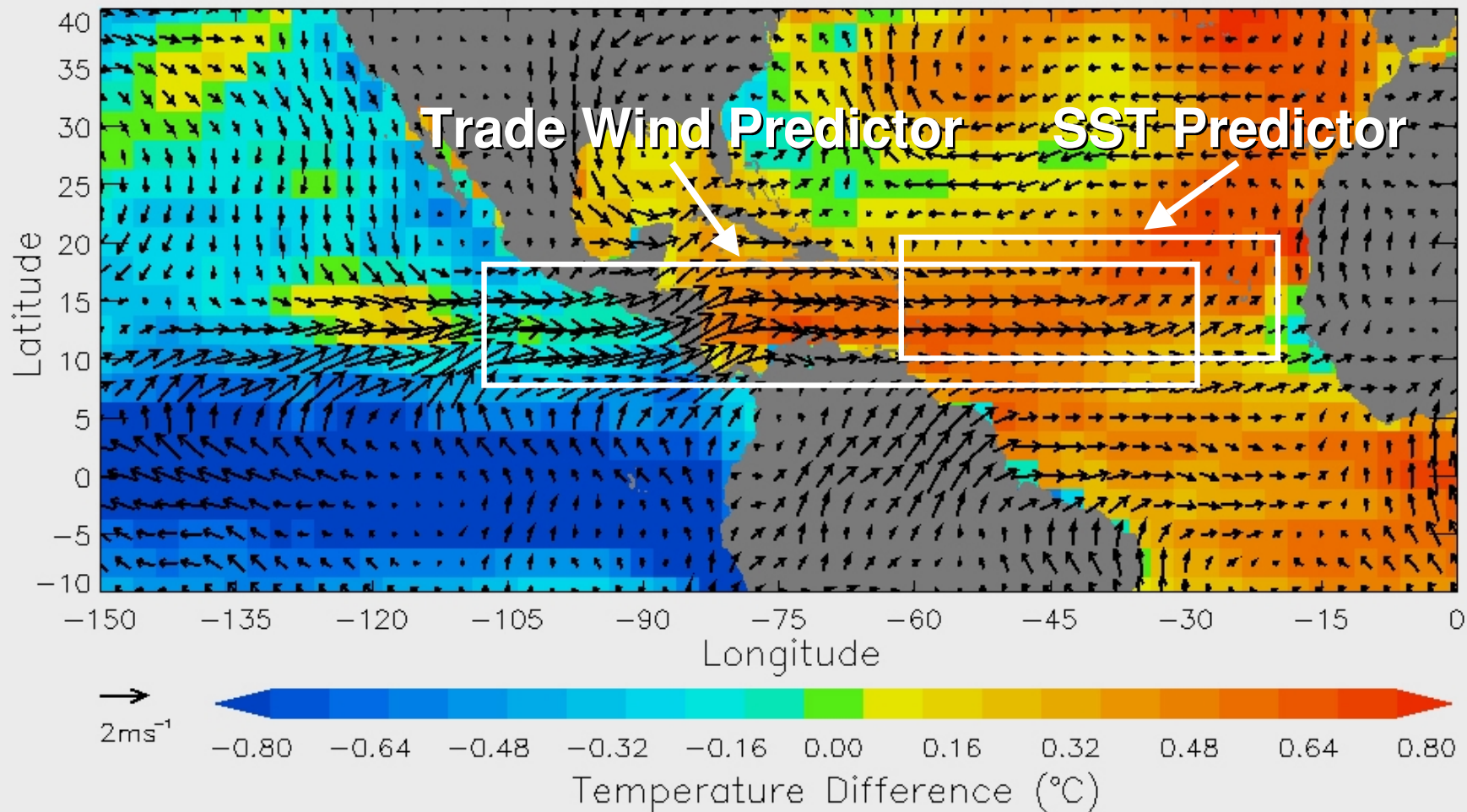


**Intense TCS = 1-min Sustained Winds > 73 mph**  
**Super Intense TCS = 1-min Sustained Winds > 110 mph**



# Atlantic Hurricane Predictors

JAS 925mb Wind and SST Anomalies: Active – Inactive Years



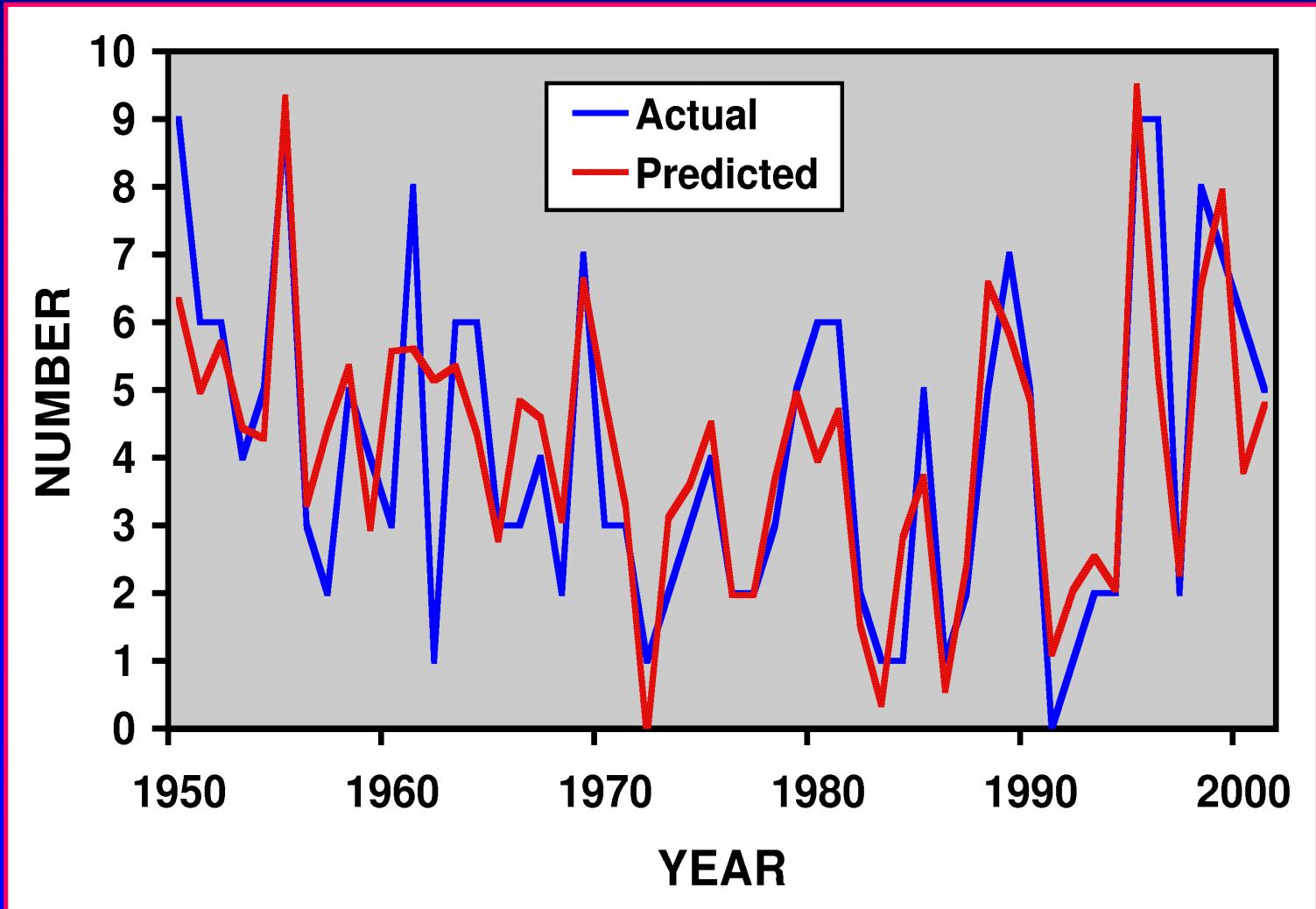


# Hurricane Numbers 1950-2001

## Tropical Atlantic, Caribbean Sea and Gulf

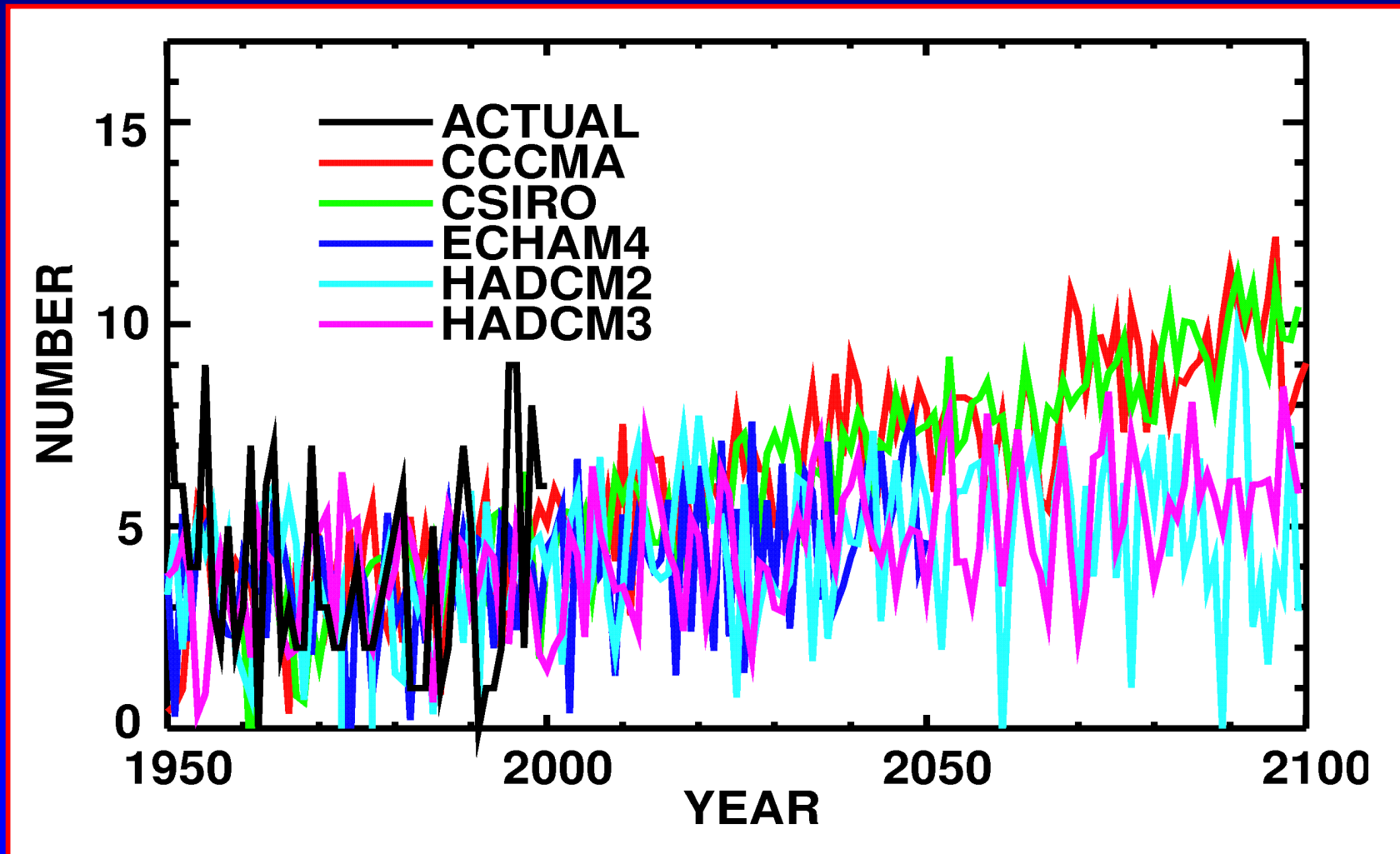
Perfect Predictors

$R^2 = 0.67$





# Future Projections for Tropical Atlantic, Caribbean and Gulf Hurricane Numbers





# Summary

- The number of Atlantic, US and Caribbean landfalling hurricanes may **rise slowly** due to global warming.
- However, the change in the mean number over the next 100 years is **likely to be small** compared to the current range of natural year-to-year variability.
- The large majority of future changes in US and Caribbean hurricane losses will continue to result from **natural interannual and decadal variability**.



## 5. Conclusions

- Seasonal forecasts of basin tropical cyclone activity are skillful enough to be used for **improved risk awareness.**
- Skill to 95% confidence exists from:
  - Early May for the Atlantic ACE Index*
  - Early May for the NW Pacific ACE Index.*
- Outlook for 2003 activity:
  - Atlantic** - above average (to 80% probability).
  - NW Pacific** - close to average.