

Hurricanes Katrina and Ivan: How Unusual and Well Predicted?

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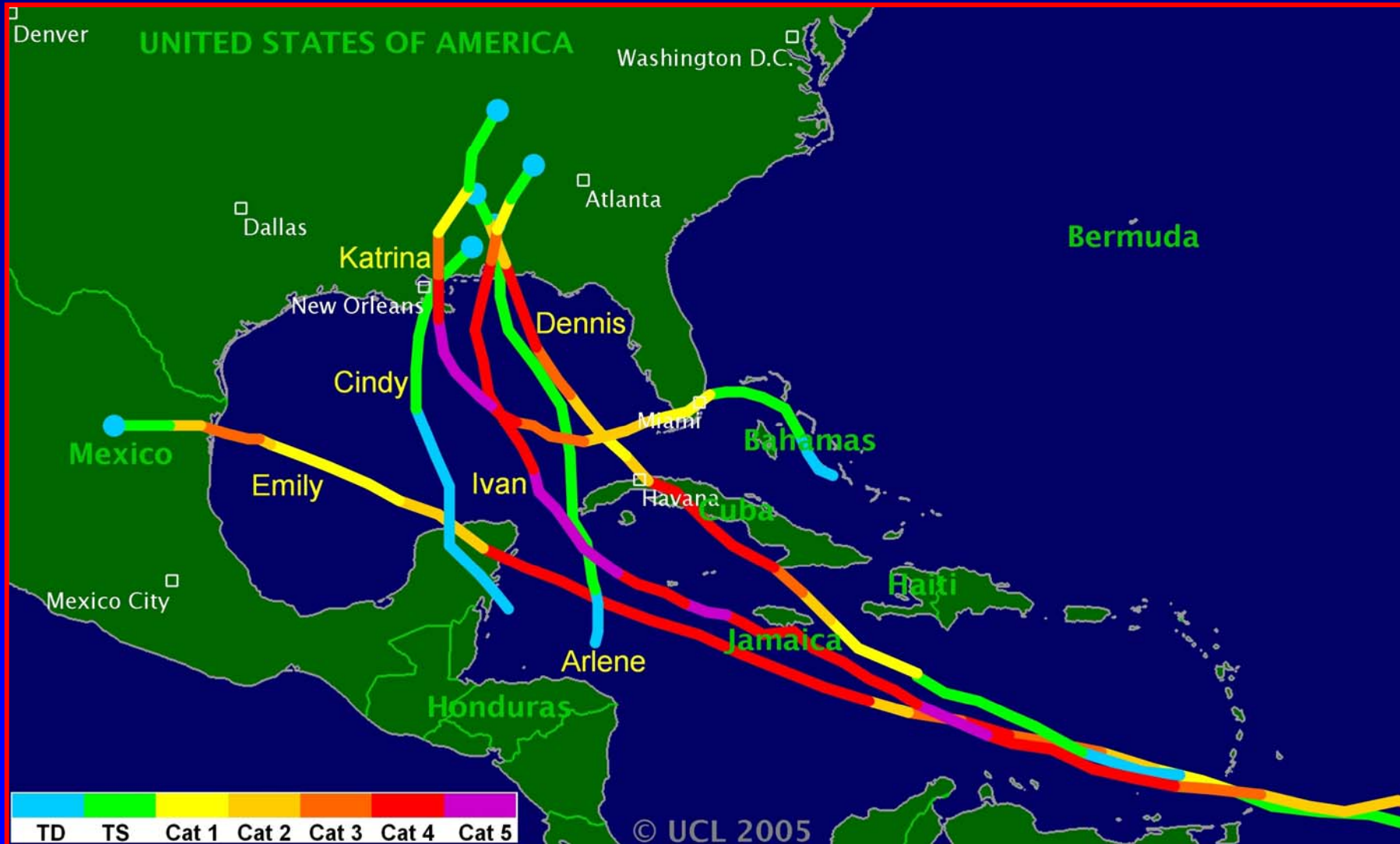


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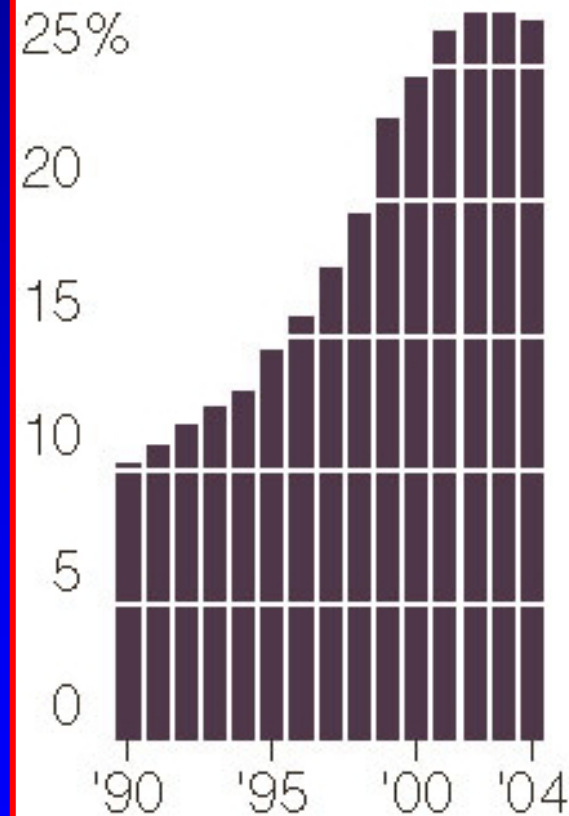
Katrina, Ivan and 2005 Storms





Importance of Gulf Oil & Gas

Gulf oil production as share of U.S. total



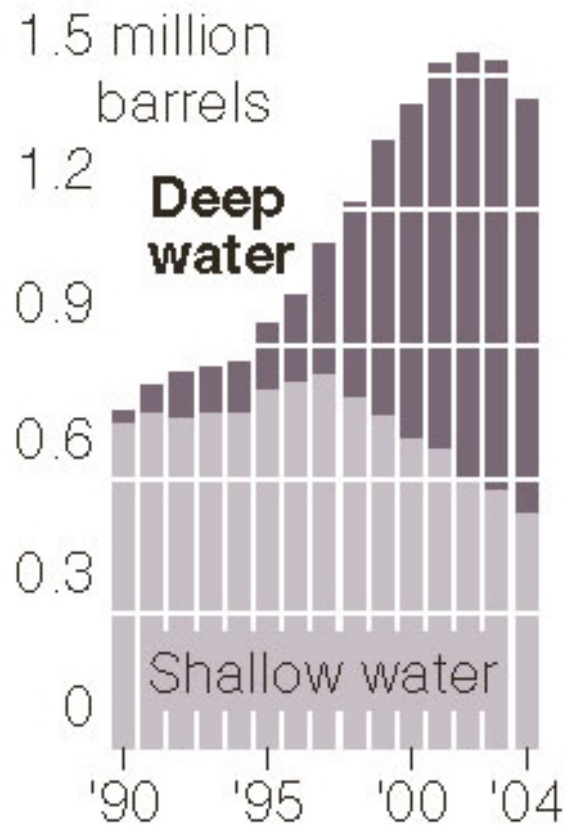
- Crucial to the US economy providing **25%** of America's energy consumption.
- Number of oil rigs and platforms in the Gulf number **4,000**.

Courtesy Minerals Management Service.

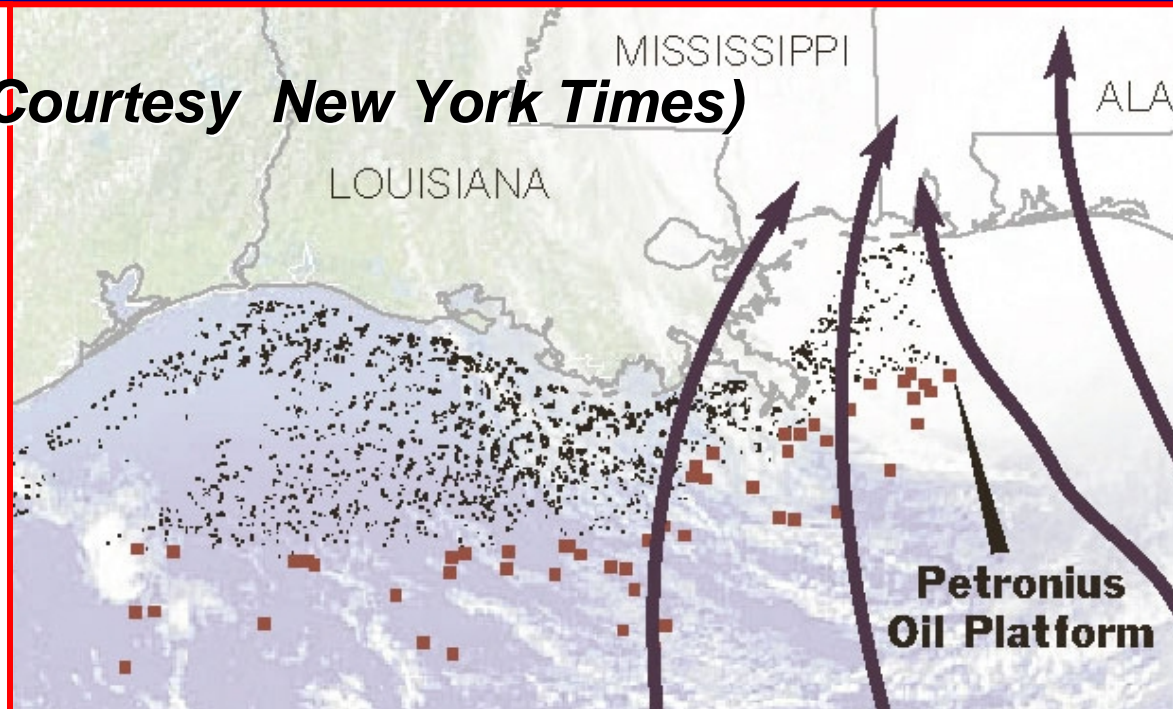


Importance of Deep Waters

Gulf oil production
by depth of water



(Courtesy *New York Times*)



- An increasing amount of oil production is coming from a small number of giant platforms in deep (over 1000ft) water.



Structure

- 1. Overview of impacts.**
- 2. How unusual were Katrina and Ivan historically?**
- 3. Harbinger of still more powerful hurricanes?**
- 4. How well predicted?**
- 5. Lessons learned**



1. Overview of Impacts



Katrina Damage

Platforms:

Destroyed **46** 'mostly low producing' energy platforms. Extensively damaged **20** others.

Drilling Rigs:

Destroyed **4** and extensively damaged a further **9**.

Pipelines:

No major damage (*U.S. Minerals Management Service preliminary report September 16*).

On Shore Refineries:

Nine were shut down and **3** remain closed.



Mars Platform

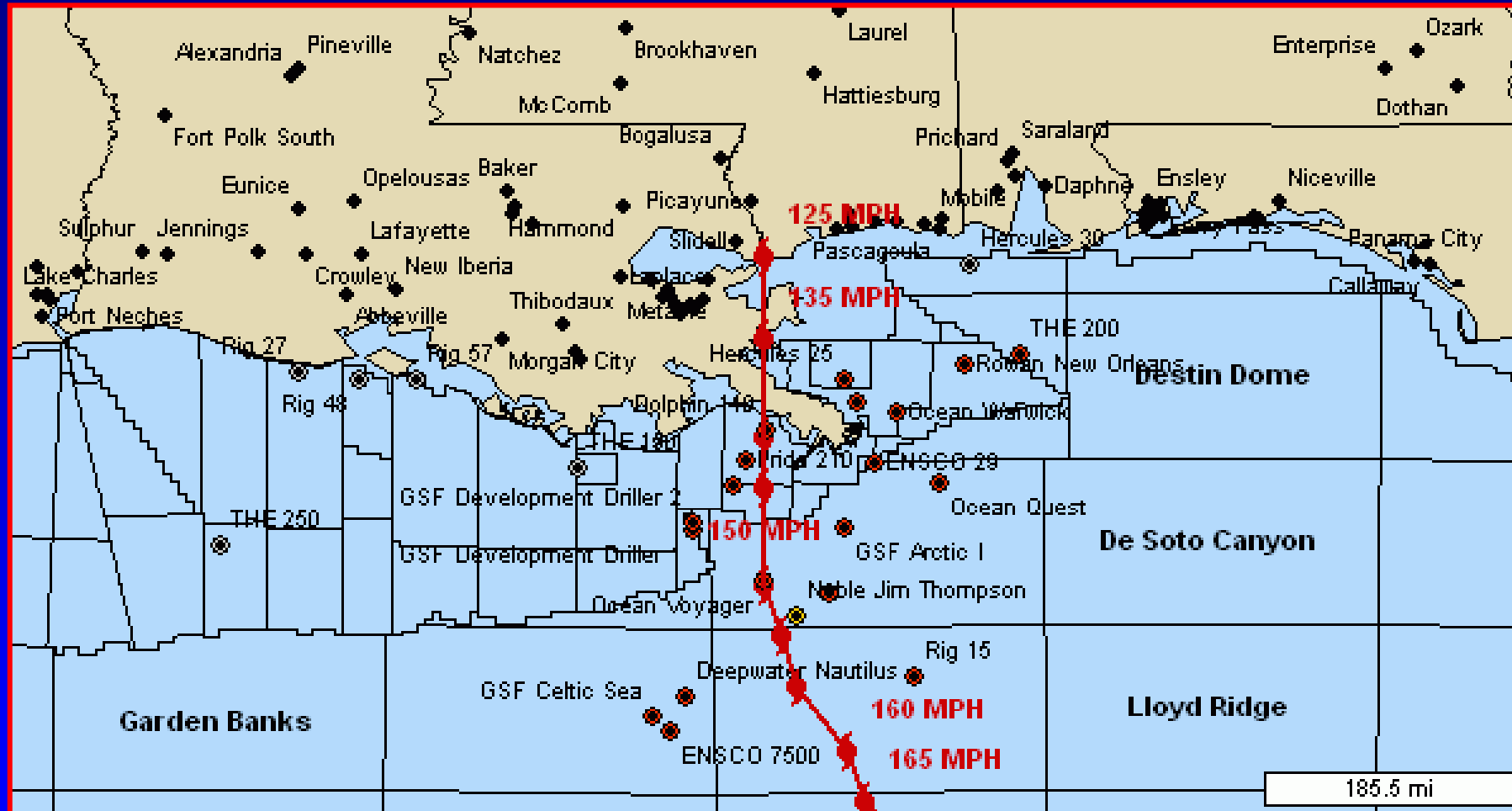
Before

After





Mobile Rigs Damaged



Courtesy RigZone.com



Ocean Warwick Rig



Rig rests by the shore in Dauphin Island, Ala. Tuesday Aug. 30, 2005 after hurricane Katrina passed through the area.



Gas Refinery





Ivan Damage

Platforms and Rigs:

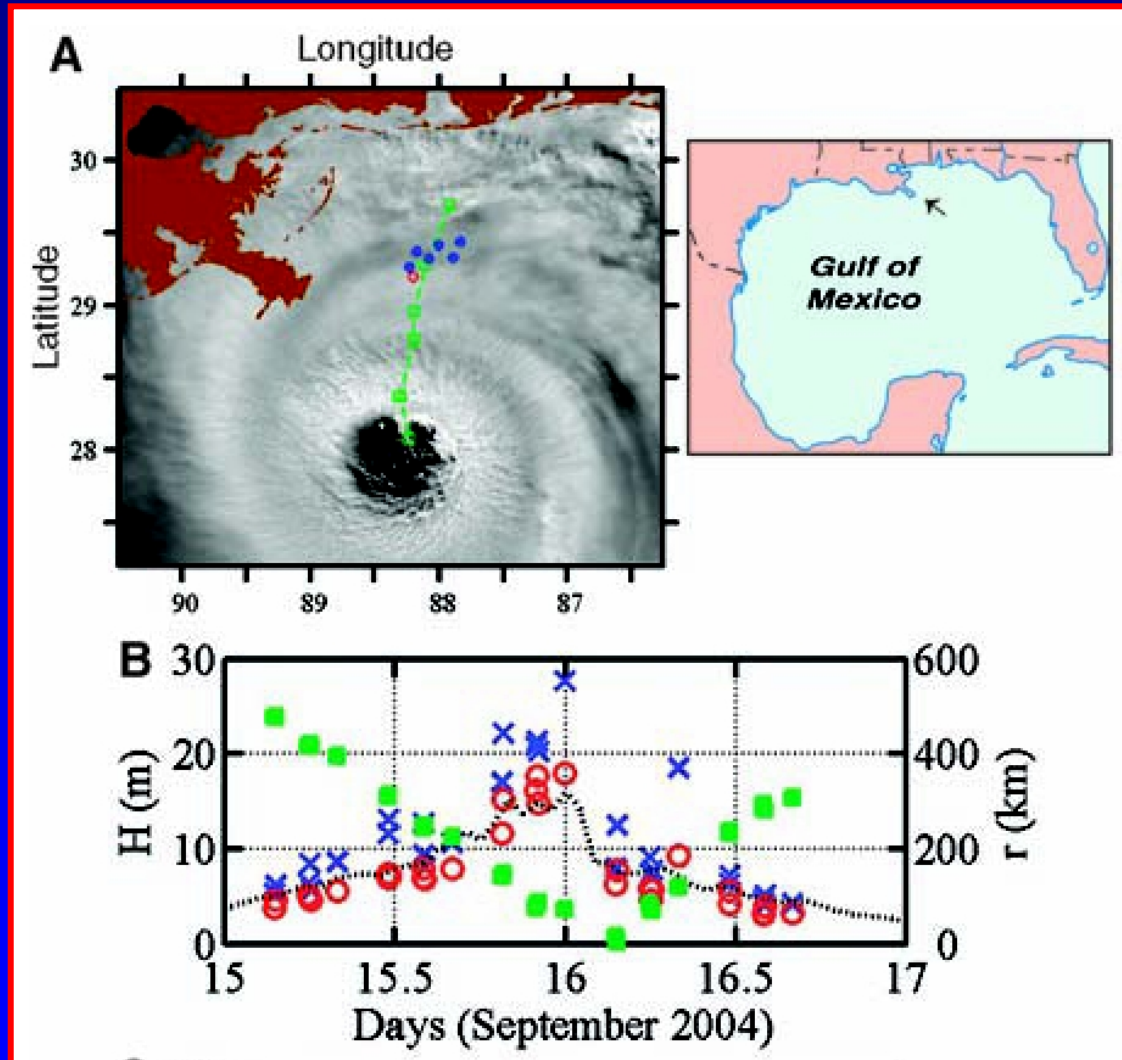
Destroyed **7** platforms and **2** rigs, and severely damaged 24 facilities. Cost an estimated **US \$ 2.7 bn** in damage.

Pipelines:

Powerful underwater mudslides damaged and buried **102** pipelines, shutting-in 45 million barrels of oil over a six-month period. Cost an estimated **US \$ 3.0 bn** in lost oil and gas revenue.



Ivan Extreme Waves



- Largest Hmax reached 27.7m (91ft).
- 24 waves measured with heights greater than 15m (50ft)

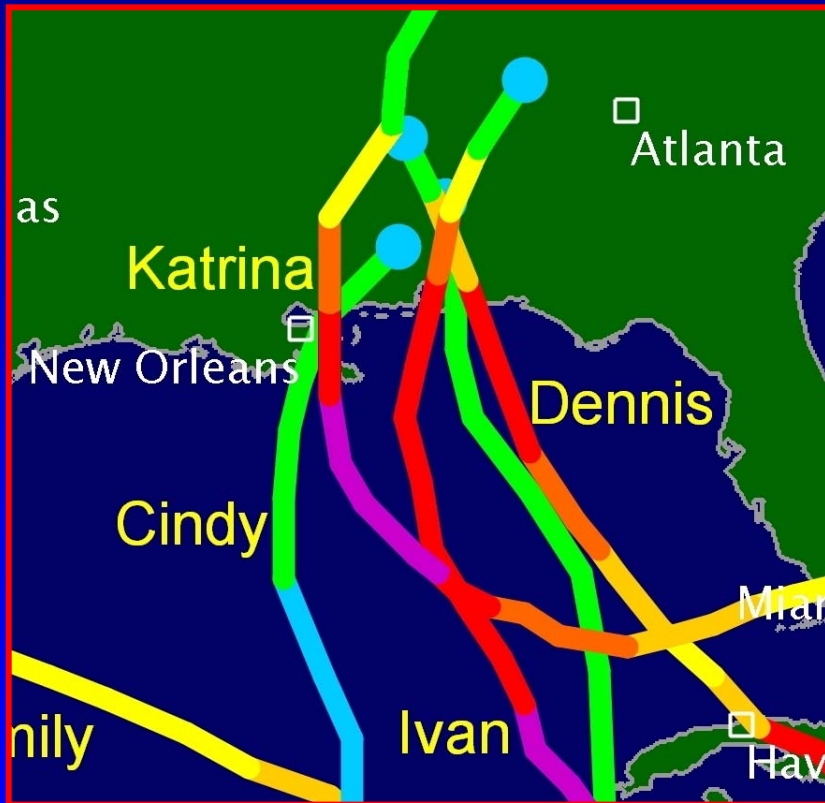
(Source: Wang et al., Science, 309, 896, 2005).



2. How Unusual Were Katrina and Ivan Historically?



Katrina and Ivan Windspeeds



1-min sustained winds when crossing the Gulf offshore energy installations:

Katrina: 150 mph

Ivan: 130 mph

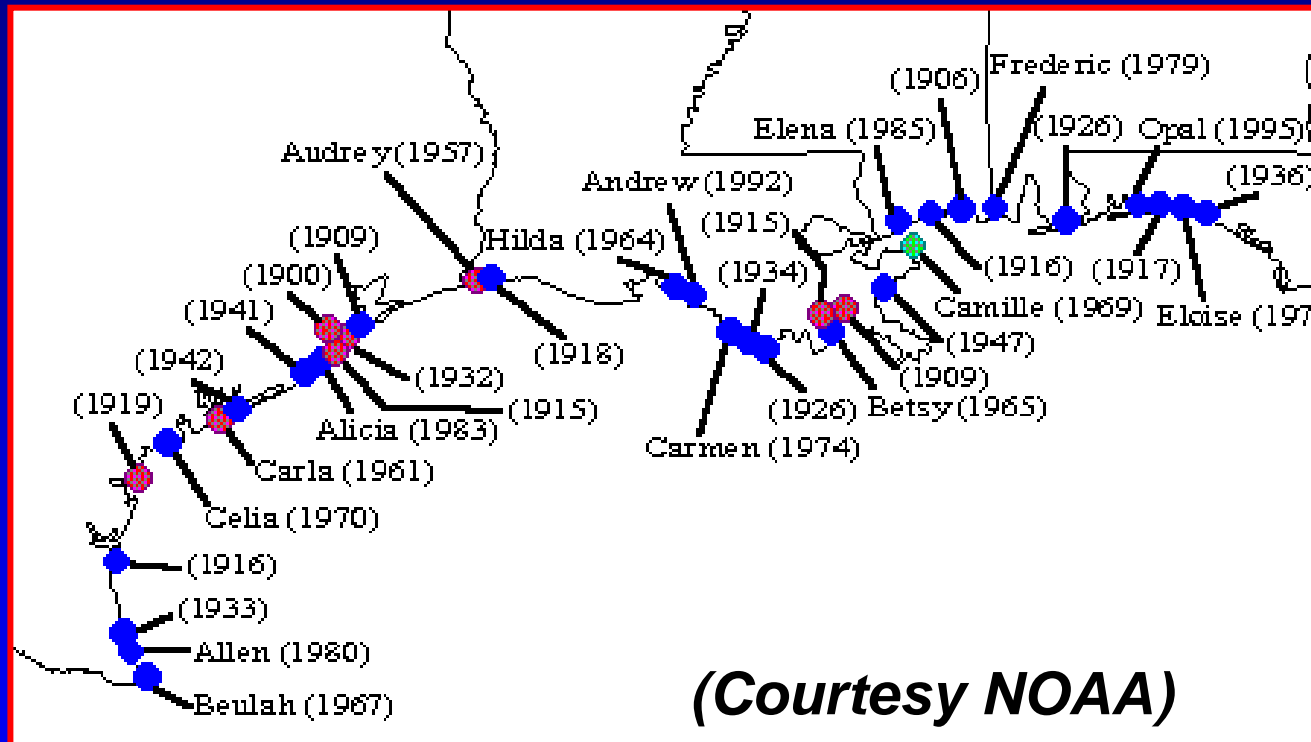
In the past decade the only previous damaging events were:

Opal (1995): 120 mph

Lili (2002): 110-120 mph



Major Gulf Hurricane Strikes 1899-1996



Saffir-Simpson Category of Landfalling Hurricanes

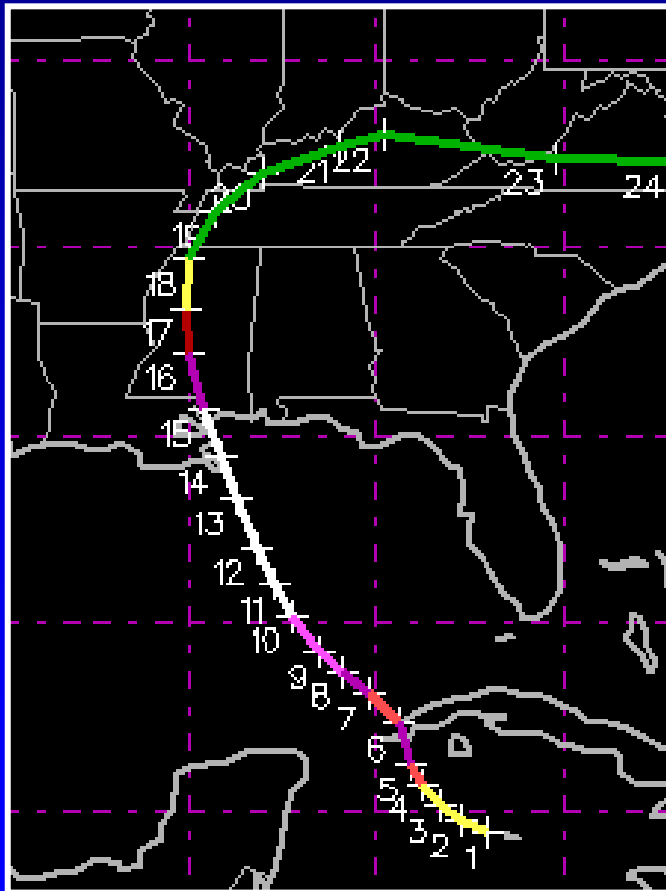
- Category 3
- Category 4
- Category 5

Since 1900 **12** hurricanes with an intensity higher than Ivan have made landfall between Pensacola (Florida) and Brownsville (Texas).



Hurricane Camille

14-22 August 1969



- Strongest US landfalling hurricane on record.
- Sustained winds of **190 mph** (gusts in the range 210-220 mph)
- Storm surge of **22-25 feet**.



Hurricane Camille Damage



Before

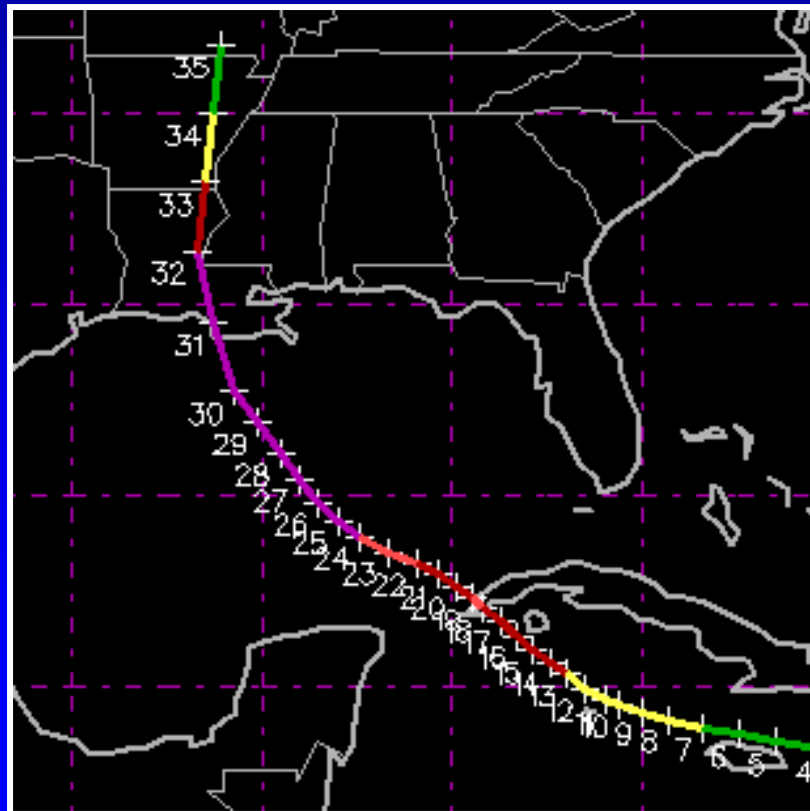


After



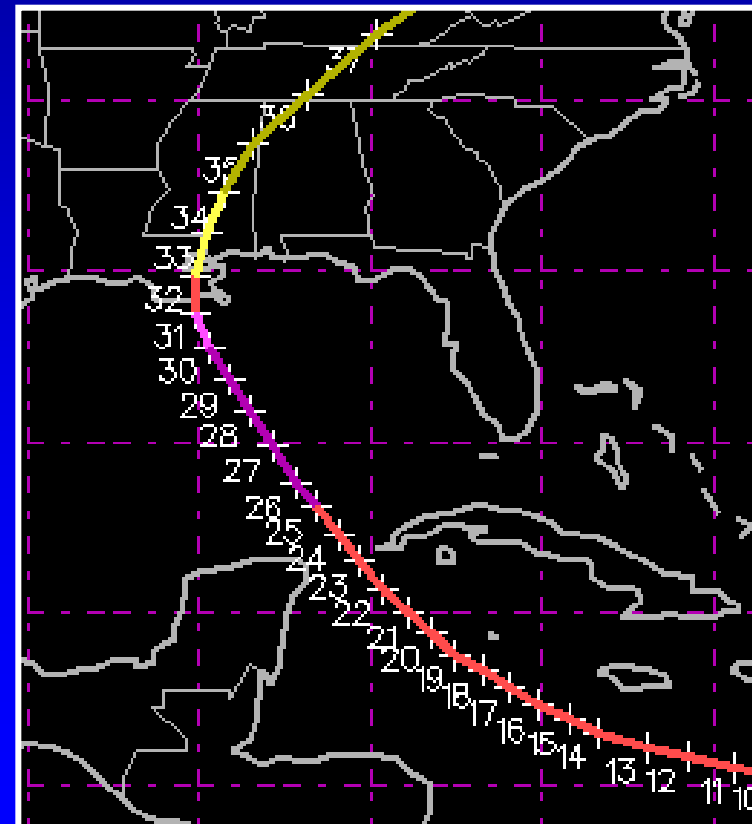
Other Cat 4 Hurricane Strikes Near Katrina Landfall

September 1909



IUMI Conference 2005

September 1915

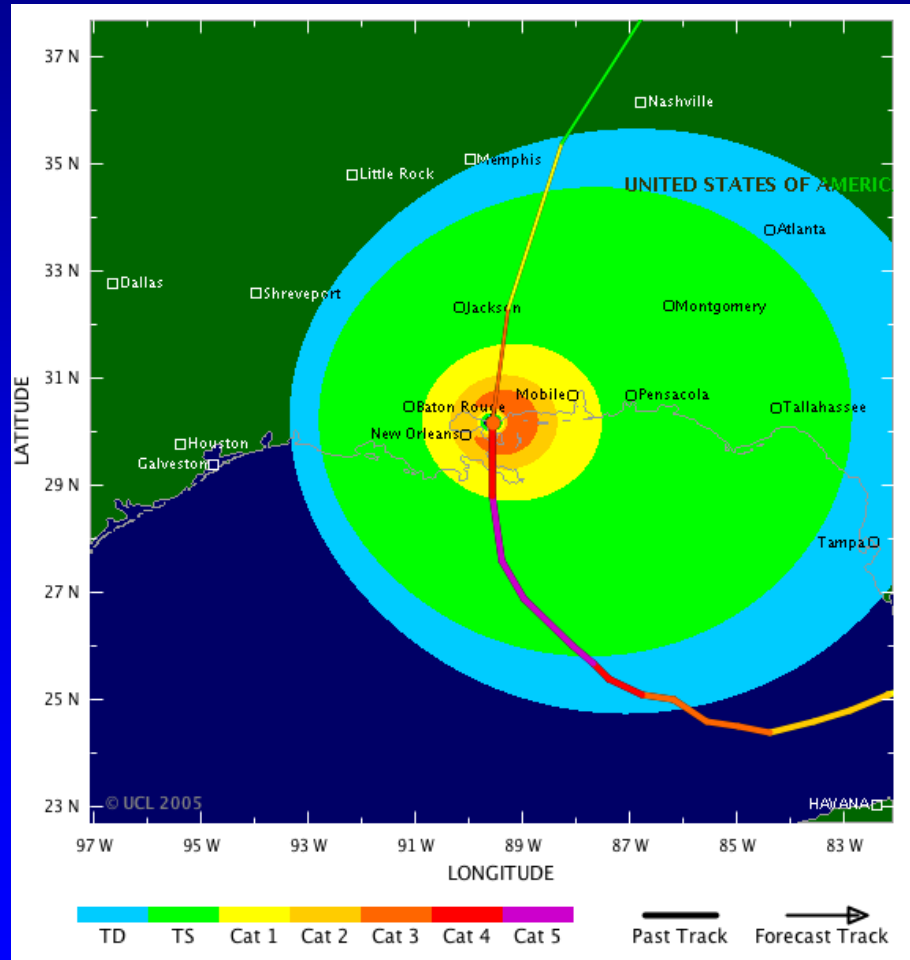


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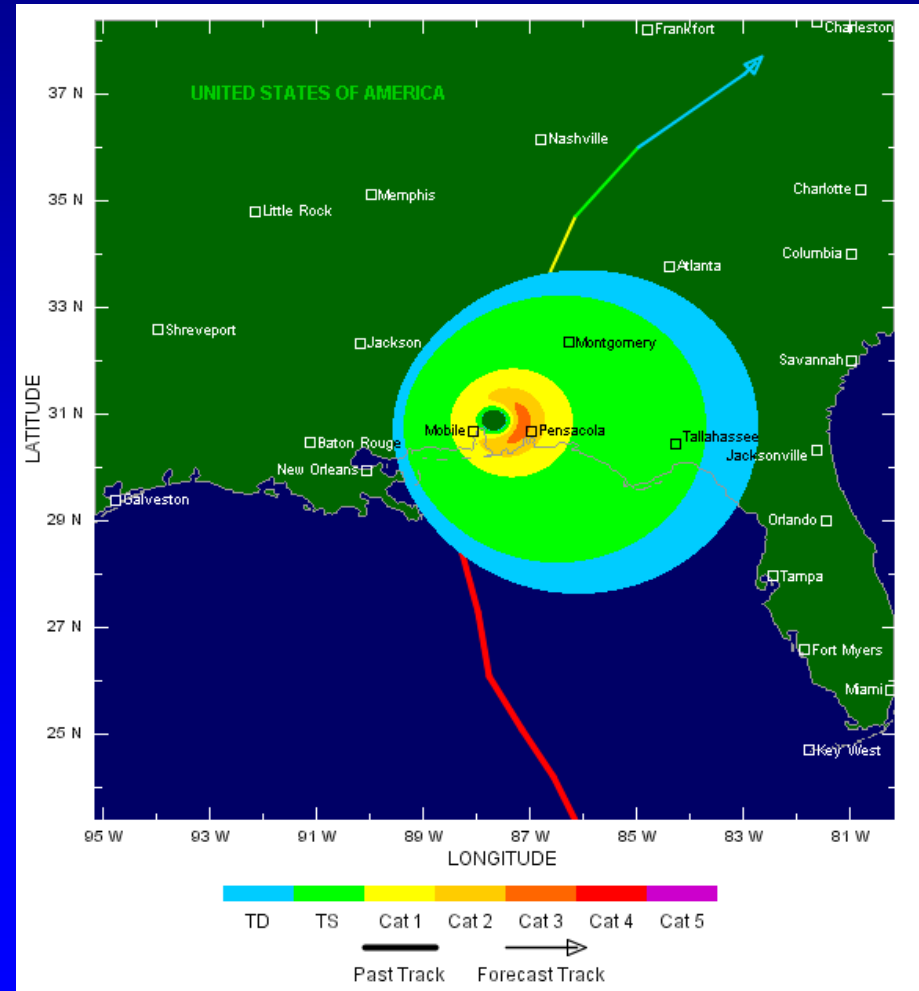


Katrina and Ivan Comparison

Katrina Windfield



Ivan Windfield





Summary

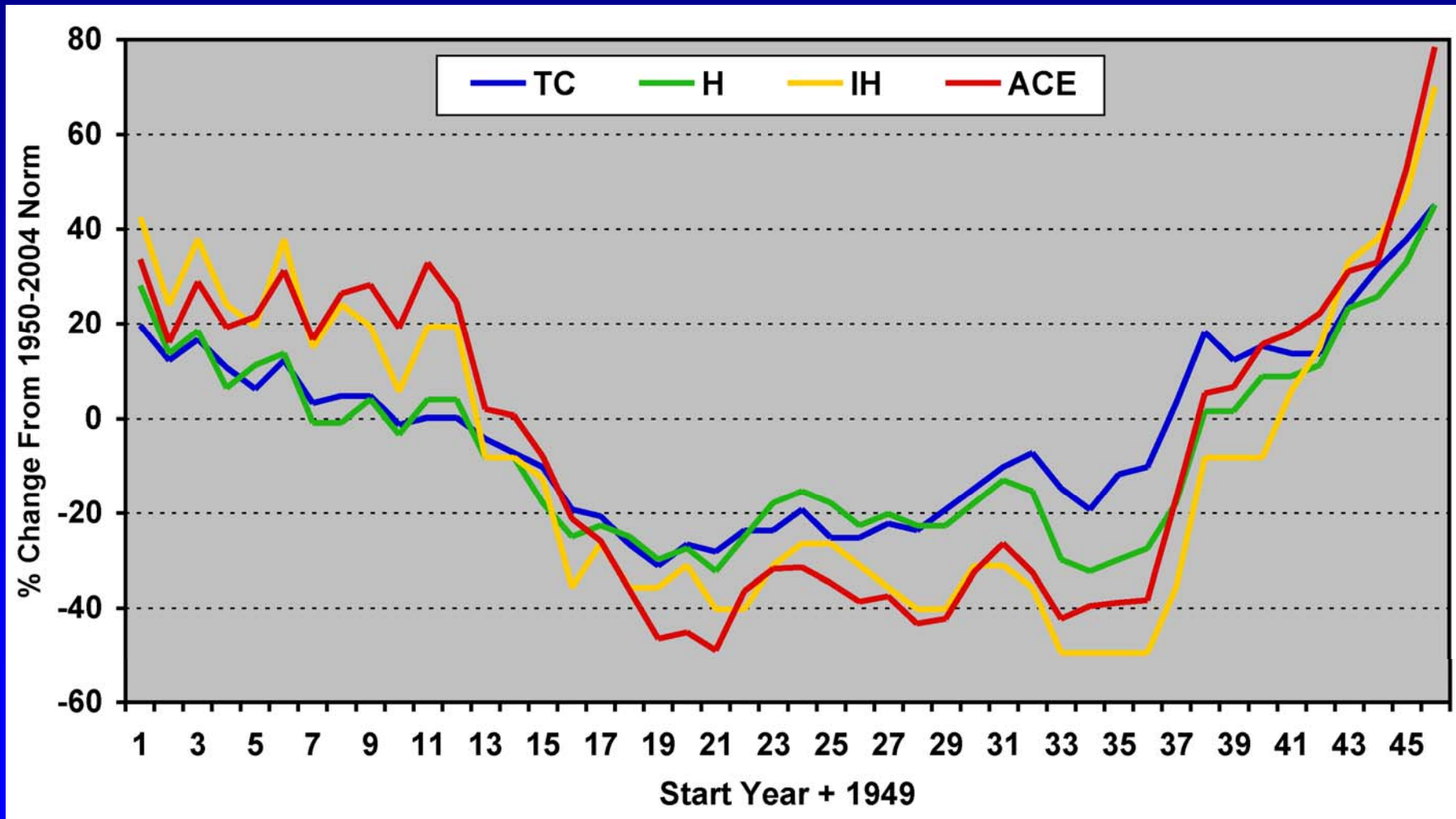
- The historical records show that hurricanes of Ivan's intensity are not uncommon and that Katrina is not the strongest hurricane to have affected the region.
- Camille's 190 mph sustained winds were 25% higher than Katrina's winds.
- Hurricanes of Katrina's strength or stronger will happen again.
- Hurricanes of Ivan's strength will affect Gulf offshore energy production at least once a decade.



3. Harbinger of Still More Powerful Hurricanes?

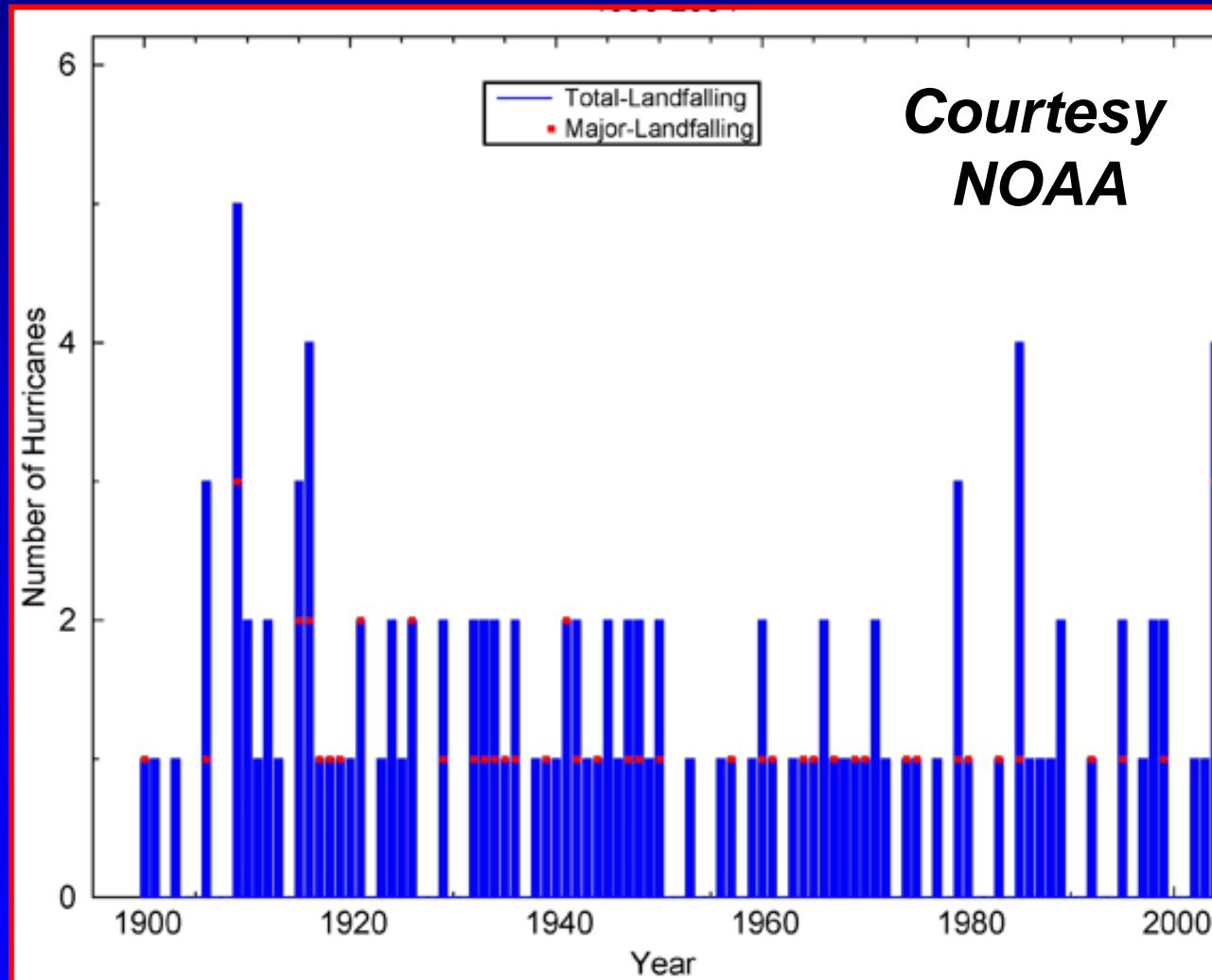


Atlantic Hurricane Activity 1950-2004 (10yr running mean)





Annual Hurricane Landfalls Along U.S. Gulf Coast 1900-2004





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 CO₂. This is line with theoretical estimates by Emanuel.

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

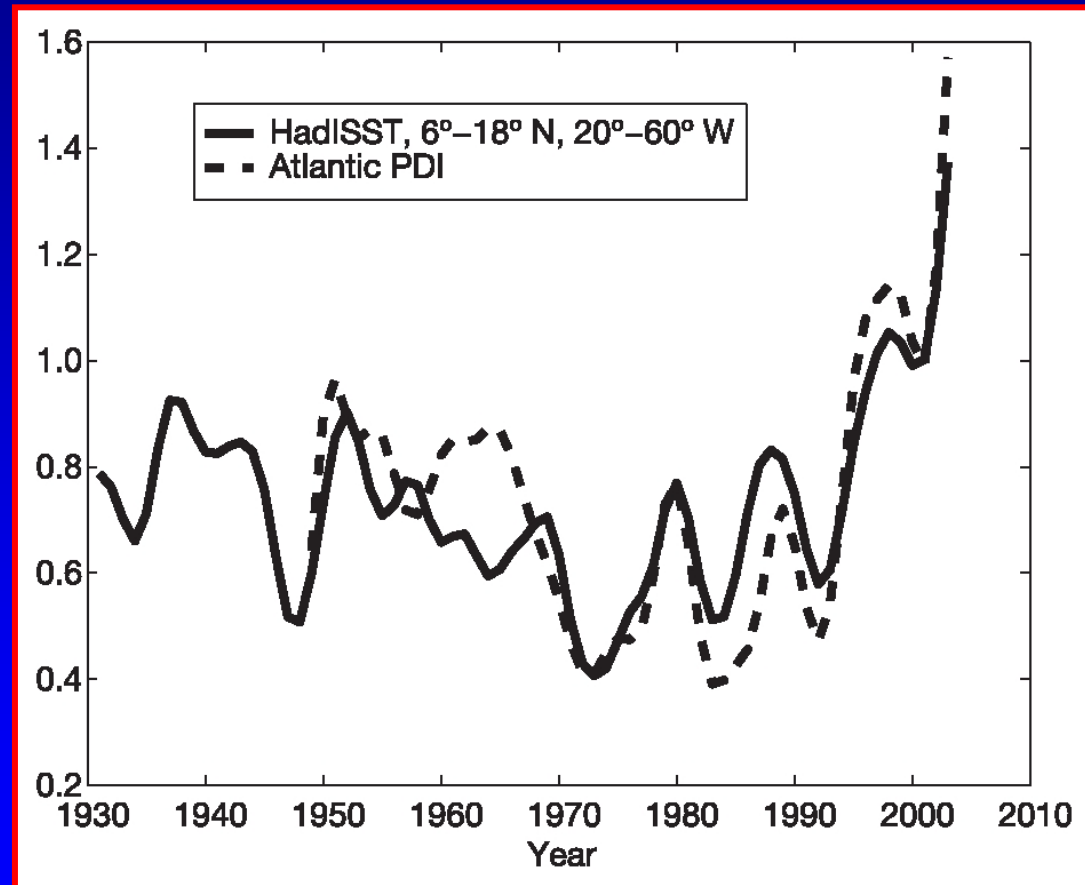
These changes may not be detectable for a few decades.



Hurricane Intensity (2)

Emanuel (2005) in a paper in *Nature* present results showing that:

The annual 'power' of Atlantic hurricane activity has increased by **100%** over the past 30 years.

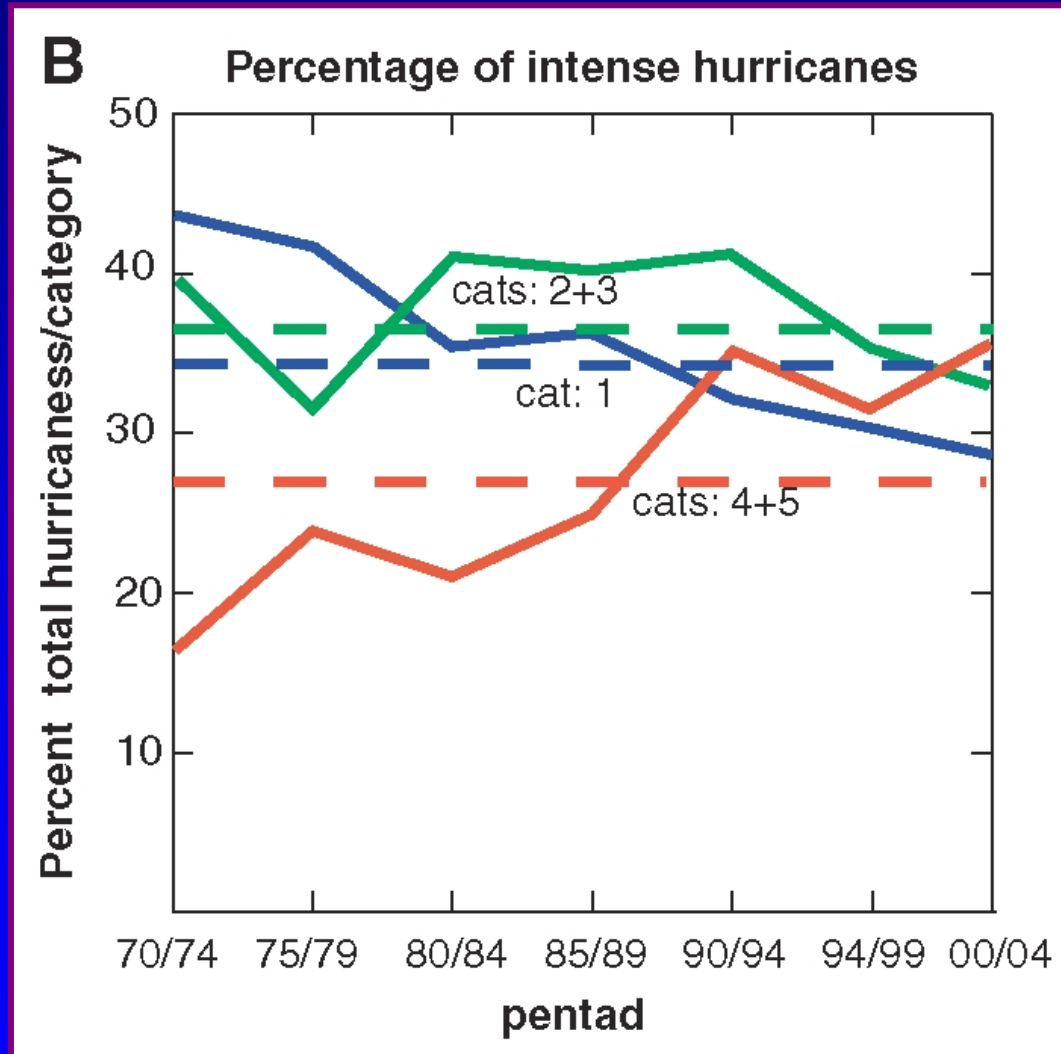




Hurricane Intensity (3)

Webster et al. (2005)
in a paper in *Science*
show that:

The number of Cat 4
and 5 strength
hurricanes
worldwide has
**increased from
about 11 per year in
the 1970s to 18
annually now.**





Summary

- **Mounting evidence suggests that tropical cyclones around the world may be intensifying, perhaps driven by greenhouse warming.**
- **(However, Katrina's damage alone can not be blamed on global warming).**
- **With the upswing in intense hurricane activity careful thought should be given to whether the 100-year design criteria for offshore platforms need to be revised.**



4. How Well Predicted?



Seasonal Forecasts - Verification (1)

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



Seasonal Forecasts - Verification (2)

Probabilistic Seasonal Forecasts: **US ACE Index 2005**

		Tercile Probabilities		
		Below normal	Normal	Above normal
Actual 2005		0	0	100
Climatology 1950-2005		33.3	33.3	33.3
TSR Forecasts	5 Aug 2005	0	15	85
	7 Jul 2005	4	14	82
	7 Jun 2005	9	21	70
	5 May 2005	8	21	71
	5 Apr 2005	9	21	70
	7 Mar 2005	9	20	71
	9 Feb 2005	11	22	67
	5 Jan 2005	10	20	70
	10 Dec 2004	13	22	65



Hurricane Prediction Model

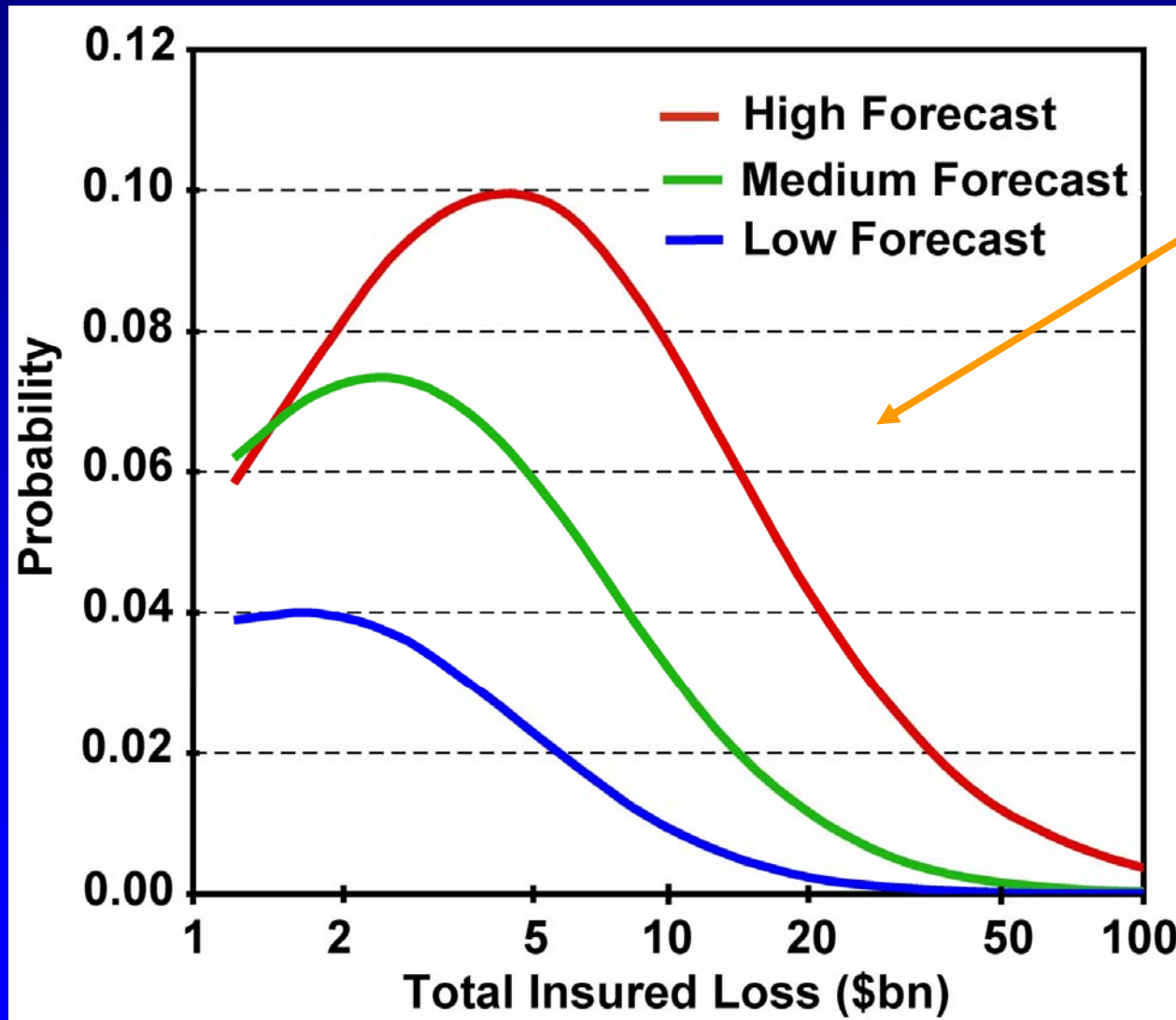
Saunders, M. A. and A. S. Lea, Seasonal prediction of hurricane activity reaching the coast of the United States, *Nature*, 434, 1005-1008, 2005.



- First example of useful skill for predicting seasonal US landfalling hurricane activity and damage.
- The model has a **sound physical basis.**
- The model will benefit risk awareness and offers good potential for **application in business decision making.**



Business Application



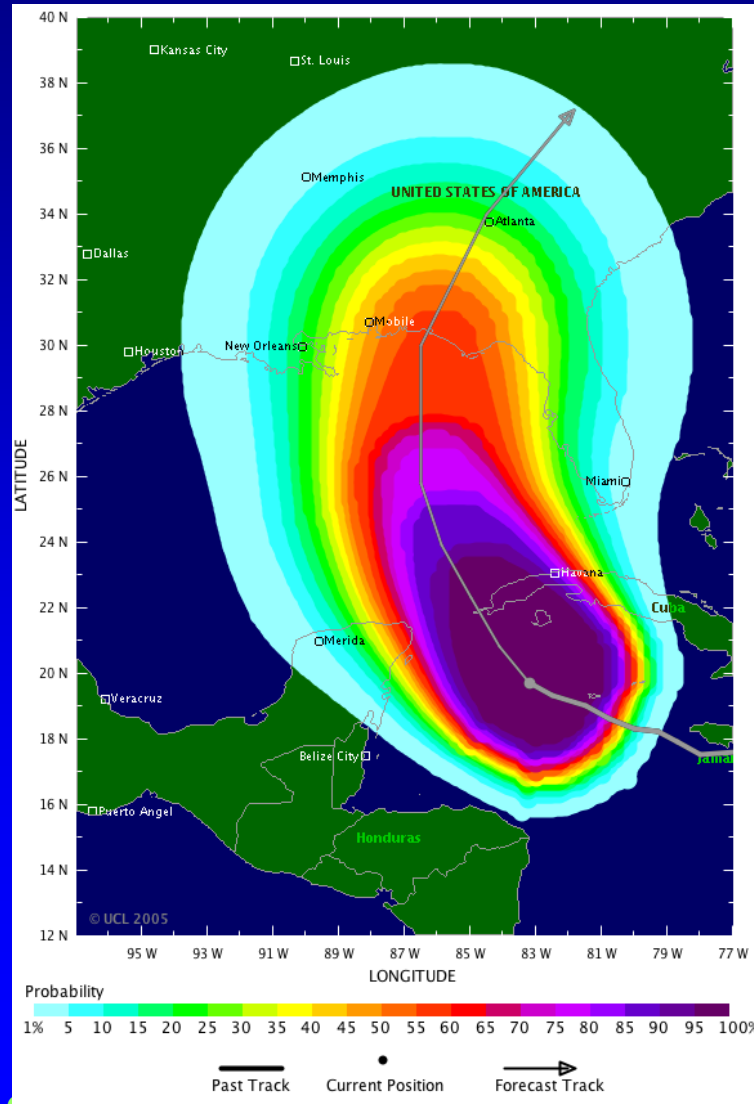
US hurricane total insured loss contingent on the TSR (Tropical Storm Risk) 1st August forecast.

The chance of a large total loss is much higher in those years when the forecast is high.

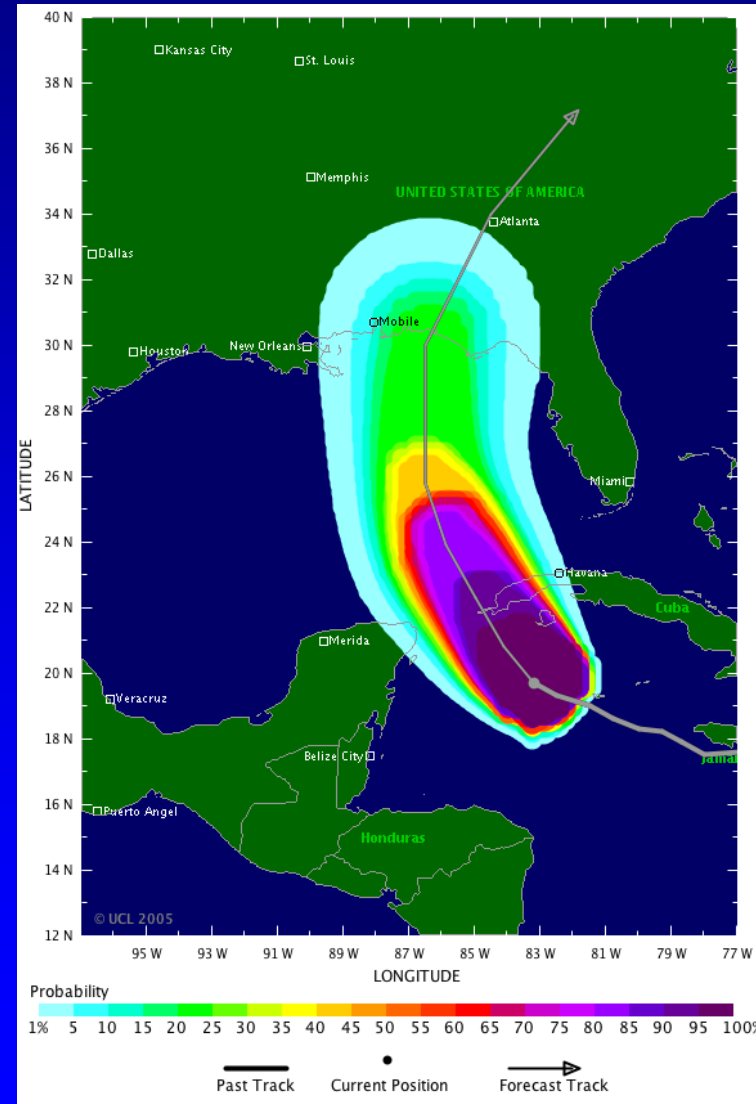


Ivan wind probability forecast

TS winds



Cat 1 winds

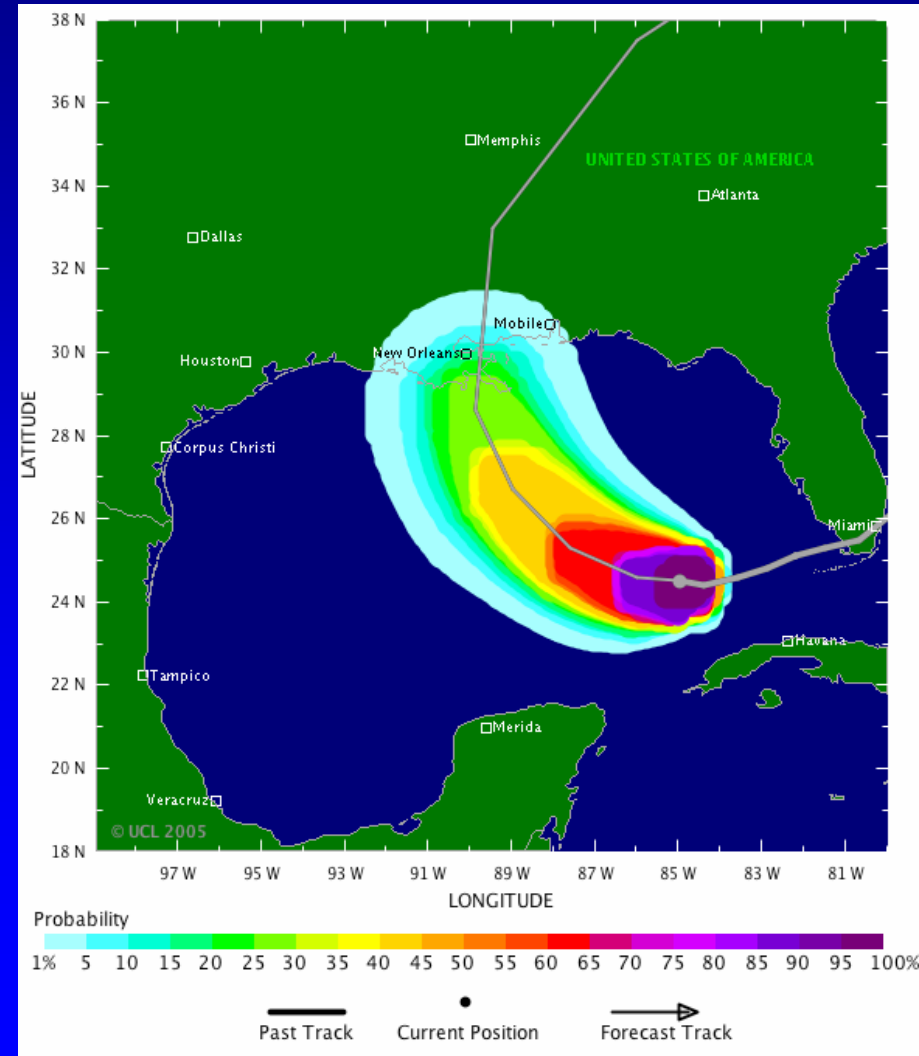
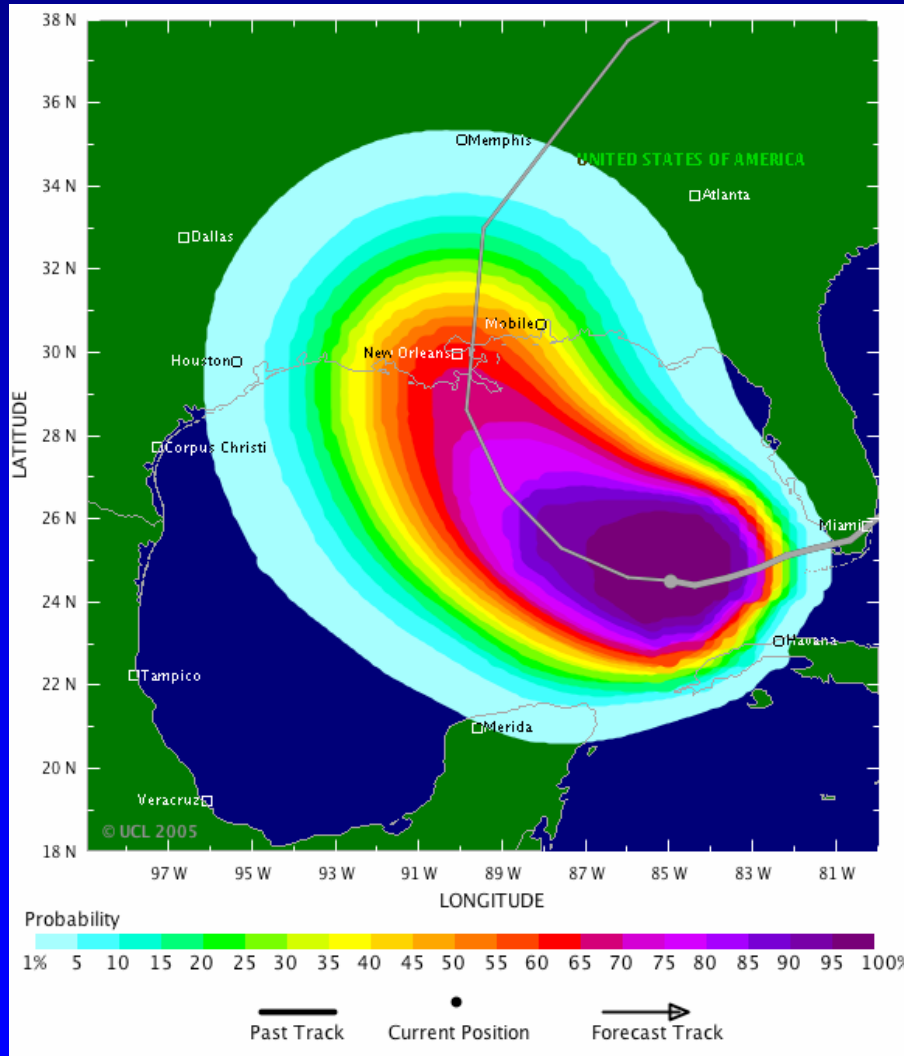




Katrina wind probability forecast

TS winds

Cat 1 winds





Benefits to Corporate Risk

- The marine, energy and power sector would have **reduced their losses in 2004 and 2005** by acting upon the TSR seasonal hurricane forecasts. These forecasts **predicted above-tercile US landfalling activity** to high probability in both years.
- The new **'wind speed probability'** graphical product will help with better preparedness decisions. The offshore industry can tell at a glance what the current chance is that a given platform/rig will be hit by damaging winds.



5. Lessons Learned



Lessons Learned

1. We are in an active phase for North Atlantic and Gulf hurricane activity:

a) Katrina was the most damaging (though not the strongest in terms of windspeed) hurricane to strike the US since reliable records began.

b) 2004 and 2005 could have the highest-ever two-year total for the number of major hurricane strikes on the US Gulf Coast.

c) Two observational studies published in past month show that the number of intense hurricanes is rising in the North Atlantic.



Lessons Learned

- 2. Hurricanes of Ivan's strength will affect Gulf offshore energy production **at least once a decade.****
- 3. The 100-year storm standards for platform criteria may need to be revised.**
- 4. **More notice should be taken of forecasts** (seasonal and short-range). Their increasing skill (witness 2004 and 2005) offers business benefit and opportunity.**



Tropical Storm Rita

