KAREN CLARK & COMPANY

Thinking Outside the Black Box™

Southwest Actuarial Forum
June 12, 2009

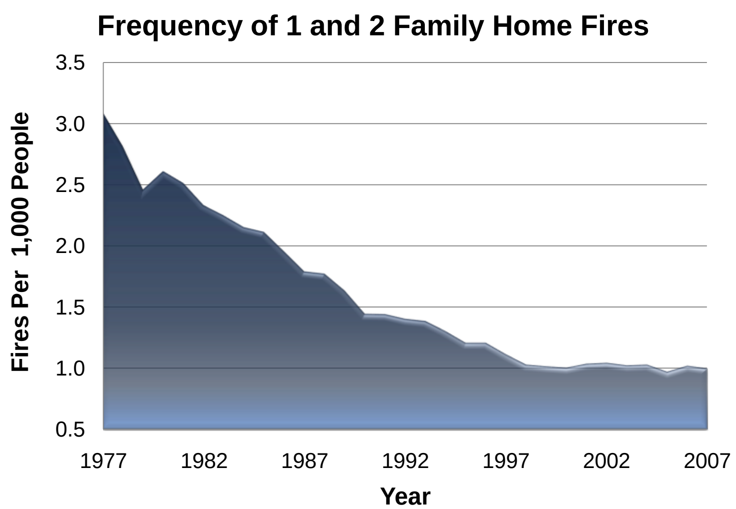
Catastrophe Losses by Year Since 1998

Year	Number of Catastrophes	Number of Claims (millions)	Dollars when Occurred (billions)	In 2007 Dollars (billions)
1998	37	3.6	$10.1	$12.8
1999	27	3.2	8.3	10.3
2000	24	1.5	4.6	5.5
2001	20	1.5	26.5	31.0
2002	25	1.8	5.9	6.8
2003	21	2.7	12.9	14.5
2004	22	3.4	27.5	30.2
2005	24	4.4	62.3	66.1
2006	33	2.3	9.2	9.5
2007	23	1.2	6.7	6.7

Source: PCS, inflation adjustment by III

© 2009 Karen Clark & Company

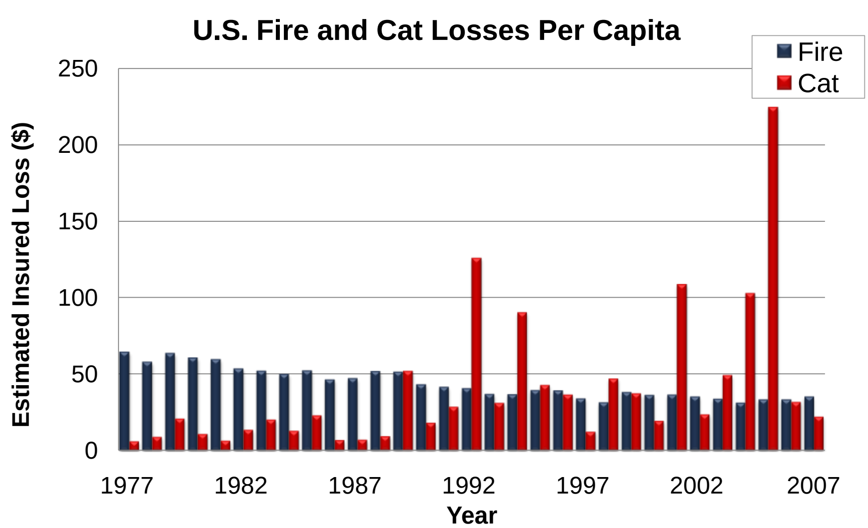
Frequency of Fire Losses is Decreasing



Source: NFPA, US Census

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

While Catastrophe Losses Are Increasing



Source: NFPA, PCS with inflation adjustment by KCC

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Biggest Driver of Increasing Hurricane Losses is Increases in Numbers, Values and Sizes of Properties in Harm's Way

Source: Florida State Archives

Source: Google Earth

KAREN CLARK & COMPANY

© 2009 Karen Clark & Company

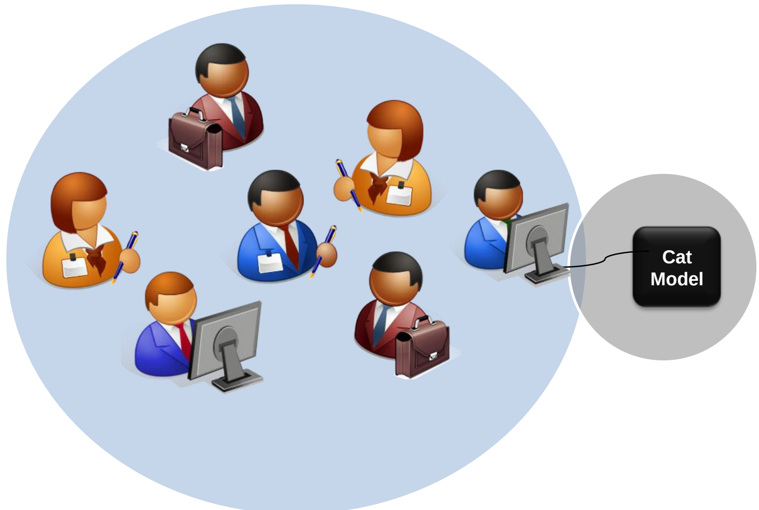
Catastrophe Models

- Standard actuarial techniques require significant historical loss information to project losses, which is not available for catastrophes
- Exposure at the time of past events varies considerably from current exposure due to changes in building codes, changes in exposure concentrations
- Catastrophe modeling combines probabilistic techniques along with scientific and engineering knowledge to estimate loss potential for catastrophic events
- Catastrophe models estimate loss potential by simulating thousands of possible events as if they were to occur today, with current building stock and insurance policy terms

KAREN CLARK & COMPANY

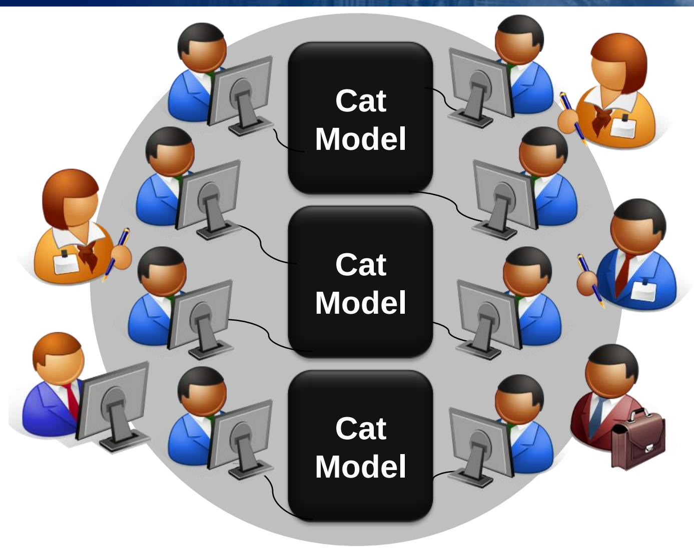
© 2009 Karen Clark & Company

The Black Box Started Out as a Useful Tool for Decision Making



© 2009 Karen Clark & Company

But Then It Grew to be Very Big and Very Powerful



© 2009 Karen Clark & Company

Catastrophe Models Provide a Guide to the Risk Not Answers or Precise Calculations of the Risk

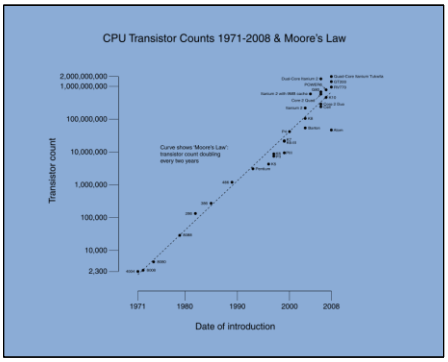
- Catastrophe models are inherently limited by limitations in our scientific knowledge
- Every model is based on simplifying assumptions and there is significant uncertainty around many of those assumptions
- Catastrophe model results are very sensitive to certain assumptions which is why the model loss estimates vary so significantly for different, scientifically valid assumptions

© 2009 Karen Clark & Company

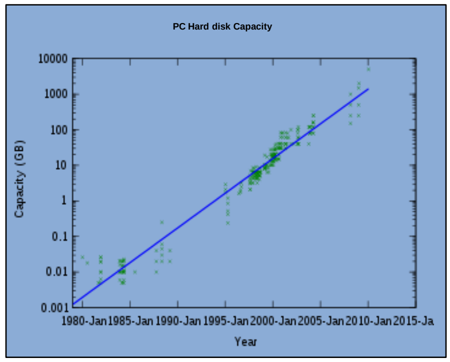
Increases in Computational Capabilities Have Enabled Ever More Complex and Detailed Models

Moore's Law and beyond …

CPU transistor counts: ↑ 2,000 times

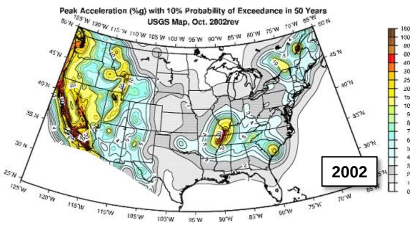


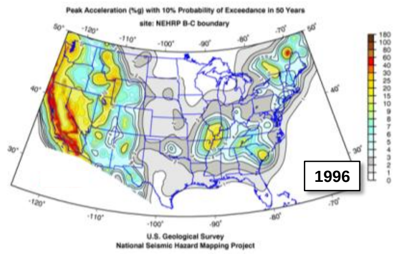
Hard-disk Capacity: ↑ 10,000 times

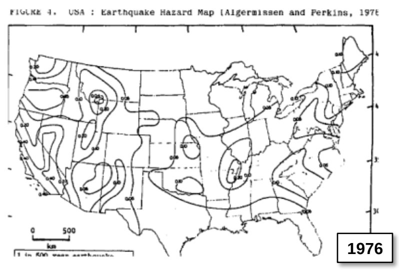


© 2009 Karen Clark & Company

How Much Has Our Knowledge of Earthquake Hazard Changed Over Past 30 Years?







KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Catastrophe Models Provide Estimates Not Answers

Create a large sample of hypothetical events Where? How big? How frequent?

↓

For each event estimate intensity at each location

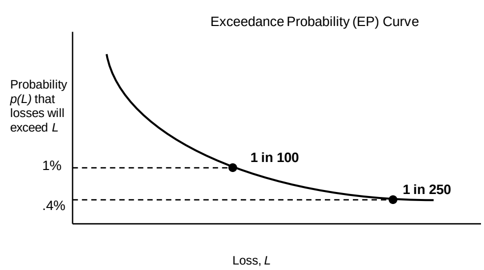
↓

Based on intensity and exposure at each location estimate damage

↓

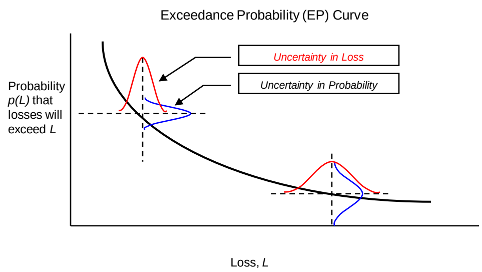
Apply policy conditions to estimate insured losses

Sim Year	Event ID	Loss ($ million)
1	1	253
1	2	41
2	1	5
3	1	1627
.	.	.
.	.	.



KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

There is Significant Uncertainty Around the EP Curve



- Uncertainty around scientific estimates of frequency and severity of large magnitude events in specific geographical areas
- “Unknowledge” with respect to ground motion, dynamics of wind speeds
- Unknowledge about how structures respond to wind and ground motion intensity
- Model and modeling error
- Data quality

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

There is Limited Scientific Data for Each Model Component

Create a large sample of hypothetical events Where? How big? How frequent?

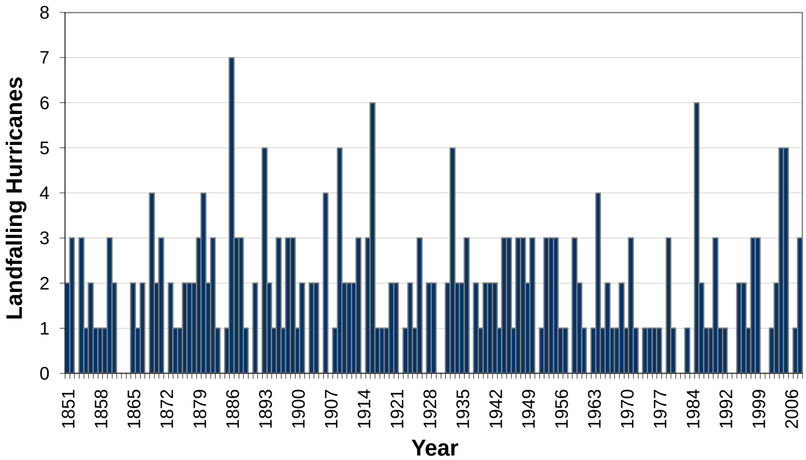
For each event estimate intensity at each location

Based on intensity and exposure at each location estimate damage

Apply policy conditions to estimate insured losses

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

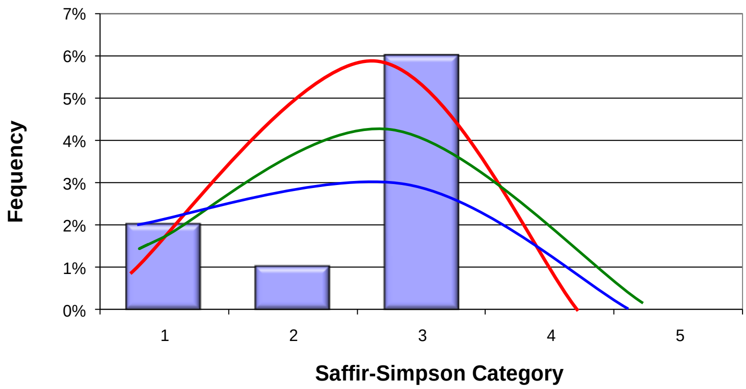
Landfalling Hurricanes Since 1851



Source: Blake, E.S., E.N. Rappaport, C.W. Landsea, 2007: The Deadliest, Costliest and Most Intense United States Tropical Cyclones from 1851 to 2006 (and Other Frequently Requested Hurricane Facts). NOAA, Technical Memorandum NWS-TPC-5, 43 pp, and National Hurricane Center Tropical Cyclone Reports. Updated to 2008 by Karen Clark & Company.

© 2009 Karen Clark & Company

Modeling the Intensity of Hurricanes by Location



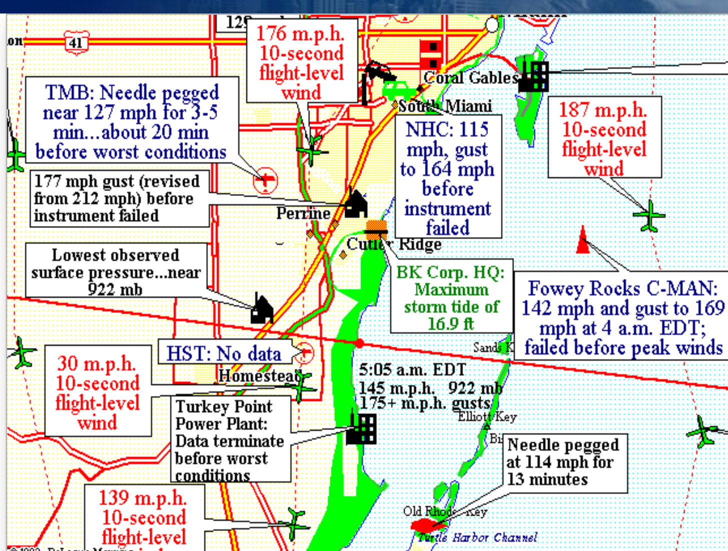
© 2009 Karen Clark & Company

After 10 Years, Hurricane Andrew Gains Strength

- August 21, 2002 – NOAA scientists announced Hurricane Andrew was even stronger than originally believed when it made landfall in south Florida 10 years ago. Based on new research, scientists upgraded the storm from a Category 4, to a Category 5, the highest on the Saffir-Simpson Hurricane Scale.
- In their re-analysis of Hurricane Andrew's maximum sustained surface-wind speeds, the NOAA/National Hurricane Center Best Track Committee, a team of hurricane experts, concluded winds were 165 mph - 20 mph faster than earlier estimated
- Dr. Mark Powell: "I disagree with the estimate of Andrew as a Cat 5 storm during any point of its history when over shallow water or land. I believe that Andrew's wind speeds were consistent with a strong Cat 4 storm at landfall in south Florida, or ~ 132 kts (152 mph). However the uncertainty of this estimate is high, +/- 26 kts (30 mph), since we know very little about sea surface roughness in extreme winds."

© 2009 Karen Clark & Company

Actual Observations for Hurricane Andrew



Source: NOAA

© 2009 Karen Clark & Company

Meteorologists Don't Know the Maximum Wind Speeds for Most Hurricanes—particularly Over Land

- Wind measuring equipment is not uniformly installed along the coast
- Anemometers fail before peak winds are measured due to power outages and other problems
- Available wind measurements are subject to significant error and frequently must be translated to a common basis—averaging time and terrain characteristics
- Peak winds are frequently inferred from other information, introducing more uncertainty
- "There is always some uncertainty in determining the maximum winds in a hurricane," said Max Mayfield, former director of the National Hurricane Center

© 2009 Karen Clark & Company

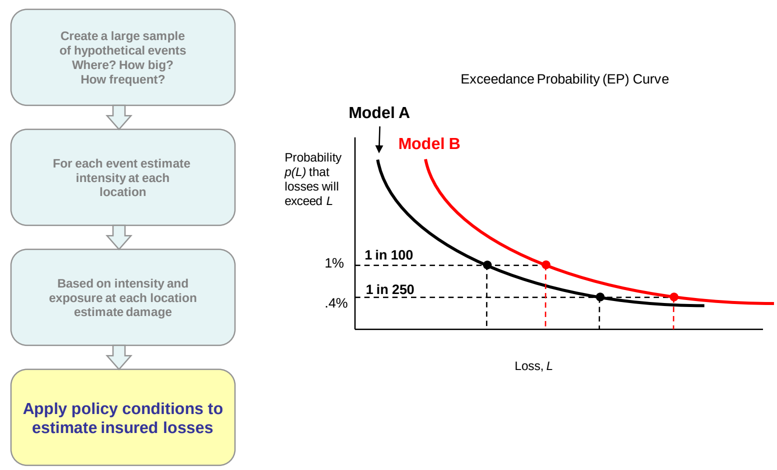
Storms Can Have Multiple Saffir-Simpson Categories

Hurricane	Year	SS Category by Wind Speed	SS Category by Central Pressure	SS Category Reconstructed Wind Field (HRD)
Alicia	1983	3	3	1-2
Andrew	1992	5	4	--
Erin	1995	2	2	1
Opal	1995	3	4	2
Fran	1996	3	3	2
Lili	2002	1	3	--
Katrina	2005	3	4	--
Wilma	2005	3	4	--

Source: HAZUS-MH MR3 Technical Manual, NHC Tropical Cyclone Reports

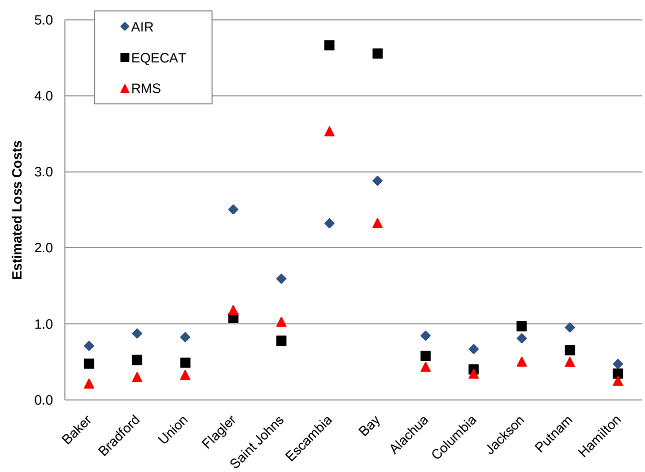
© 2009 Karen Clark & Company

By the End of the Process, Different Models Can Produce Very Different EP Curves



© 2009 Karen Clark & Company

Comparison of 2007 Florida Hurricane Model Results for Long Term Models



Source: Florida Commission on Hurricane Loss Projection Methodology – 2007 Model Submissions

© 2009 Karen Clark & Company

Catastrophe Model Estimates for Hurricanes Gustav and Ike

Model Vendor	Gustav Industry Loss Estimate ($B)	Ike Industry Loss Estimate ($B)
AIR	2 – 4.5	8 to 12
EQE	6 - 10	8 to 18
RMS	3 - 7	6 to 16
PCS Estimate	2.1	11.5

Note: Model vendors update their insured loss estimates over time. The table above summarizes onshore loss estimates at the time of landfall. PCS estimates as of Dec. 2008 for Gustav and Feb. 2009 for Ike.

© 2009 Karen Clark & Company

Modeling Fallacies and Modeling Malpractice

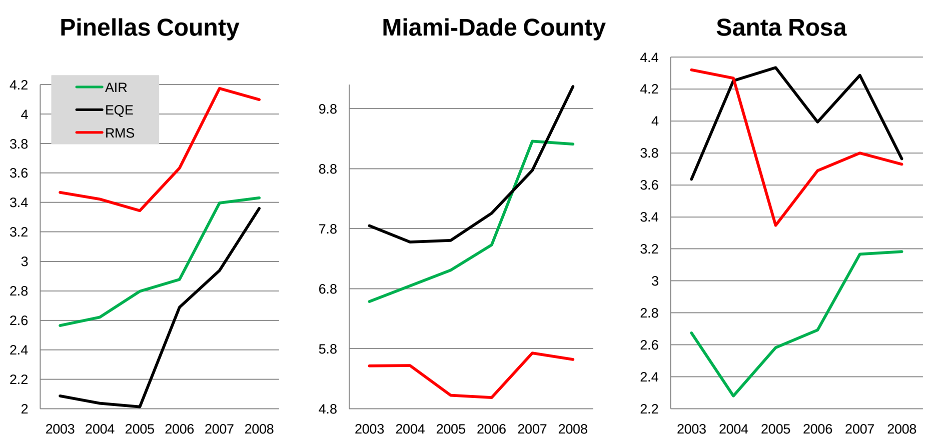
- **More detail means more accuracy**
- **I can optimize my portfolio by canceling all the policies the model says are “bad”**
- **Model updates produce better loss estimates**
- **Models can accurately predict hurricane activity over a one, two or five year time horizon**

© 2008 Karen Clark & Company

What is the Distance to Coast?

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Comparison of Florida Hurricane Model County Results 2003 to 2008

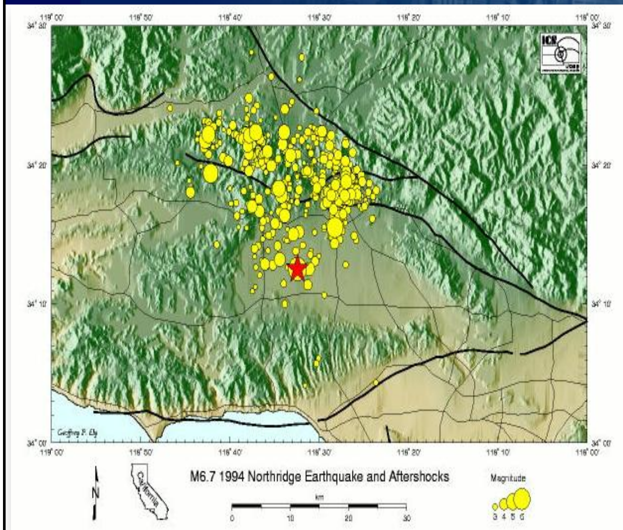


Source: Florida Commission on Hurricane Loss Projection Methodology – 2003 to 2008 Model Submissions

Loss Costs per $1,000

KAREN CLARK & COMPANY
© 2008 Karen Clark & Company

Remember Northridge



- Caused by a previously unknown fault
- Demonstrated that blind thrust faults might be more common and destructive than previously believed

Source: Institute for Crustal Studies

© 2009 Karen Clark & Company

Almost Half of $40 Billion Property Damage from Northridge was to Wood Frame Structures

- Newer buildings had more, not less damage, than older ones
- A third of the seismic feature required by UBC are flawed or missing in half of the buildings
- Architectural configurations have become more adventuresome

Professor Goety Schierle of the University of Southern California

© 2009 Karen Clark & Company

Standards and Best Practices for Effective and Efficient Catastrophe Risk Management

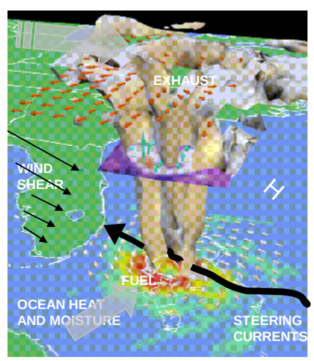
- Catastrophe models are one component of the risk assessment and management process
- Senior management develops an independent, a priori view of catastrophe loss potential based on other information
- Catastrophe model results are dissected, fully vetted and tested for credibility
- Catastrophe model results are combined with other independent information, actuarial and underwriting analyses
- Reliable, robust risk management decisions are made

© 2009 Karen Clark & Company

Predicting Hurricane Activity

- Sea surface temperatures (SSTs)
- Wind Shear (El Nino, La Nina)
- Atlantic Multi Decadal Oscillation (AMO)
- Dust storms off the Sahara

STRATOSPHERIC WINDS



Source: NOAA

© 2009 Karen Clark & Company

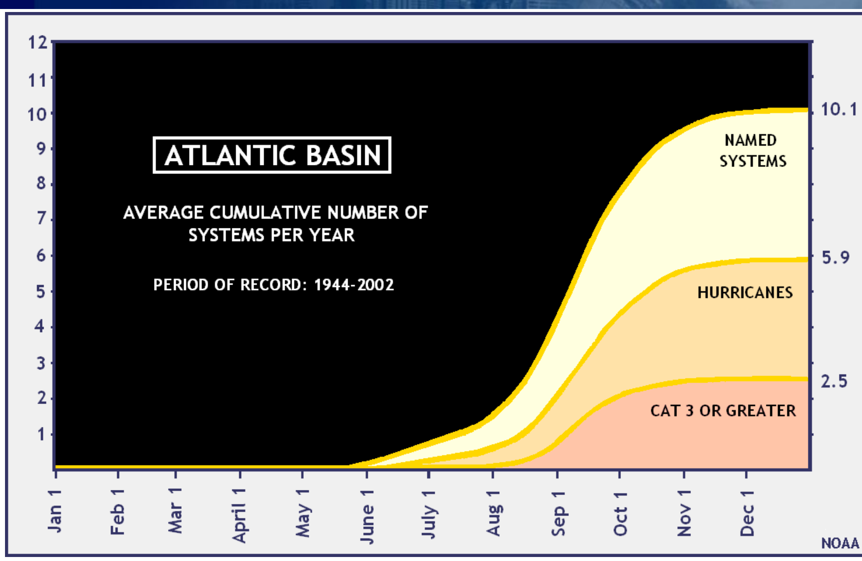
Atlantic Hurricane Predictions 2006

Agency	Forecast Date	Named Storms	Hurricanes	Major Hurricanes
NOAA	May 2006	13 – 16	8 – 10	4 – 6
NOAA	August 2006	12 - 15	7 - 9	3 - 4
CSU	April 2006	17	9	5
CSU	August 2006	15	7	3
TSR	April 2006	15.4	8.2	3.8
TSR	August 2006	15.9	7.9	3.5
Actual	**--**	**10**	**5**	**2**

NOAA – National Oceanic and Atmospheric Administration
CSU – Colorado State University
TSR – Tropical Storm Risk

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Average Atlantic Basin Tropical Cyclone Activity



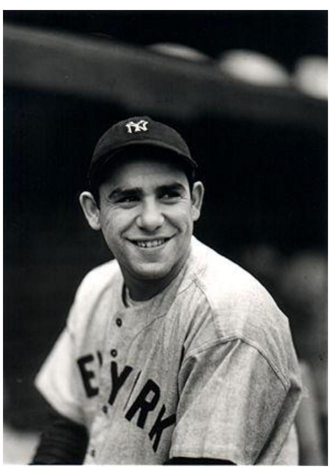
KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Atlantic Hurricane Predictions 2007

Agency	Forecast Date	Named Storms	Hurricanes	Major Hurricanes
NOAA	May 2007	13 – 17	7 – 10	3 - 5
NOAA	August 2007	13 – 16	7 – 9	3 - 5
CSU	April 2007	17	9	5
CSU	August 2007	13	8	4
TSR	April 2007	16.7	9.2	4.2
TSR	August 2007	14.7	7.8	3.5
Actual	**--**	**15**	**6**	**2**

© 2009 Karen Clark & Company

With Respect to Hurricane Predictions



As Yogi Berra said:

"Prediction is very hard — especially when it's about the future"

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

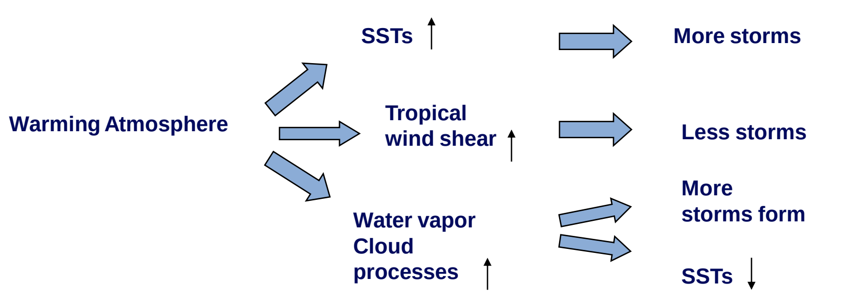
Atlantic Hurricane Predictions 2008

Agency	Forecast Date	Named Storms	Hurricanes	Major Hurricanes
NOAA	May 2007	12 – 16	6 - 9	2 - 5
NOAA	August 2007	14 – 18	7 – 10	3 - 6
CSU	April 2007	15	8	4
CSU	August 2007	17	9	5
TSR	April 2007	14.8	7.8	3.5
TSR	August 2007	18.2	9.7	4.5
As of 1/2009	**--**	**16**	**8**	**5**

© 2009 Karen Clark & Company

Why It's Difficult to Project Hurricane Activity

Atmosphere is very complex and has many feedback mechanisms



Even the most sophisticated climate models cannot capture precisely every variable and physical process in the atmosphere

© 2009 Karen Clark & Company

Most Recent IPCC Findings and Projections

- **Best estimate range of projected temperature increase by the end of this century is 3.1 to 7.2 degrees Fahrenheit (total range is 2 to 11.5)**
- **Tropical cyclones are likely (>66%) to become more intense, with higher peak wind speeds and heavier precipitation (most likely range 2 to 5 percent increase in peak wind speeds over next 20 years)**
- **Most climate models project global *decrease* in tropical cyclone frequency**

KAREN CLARK & COMPANY
© 2008 Karen Clark & Company

Are We Experiencing an Increase in North Atlantic Tropical Cyclone Activity?

Trends in Atlantic Basin Tropical Cyclone Storm Counts

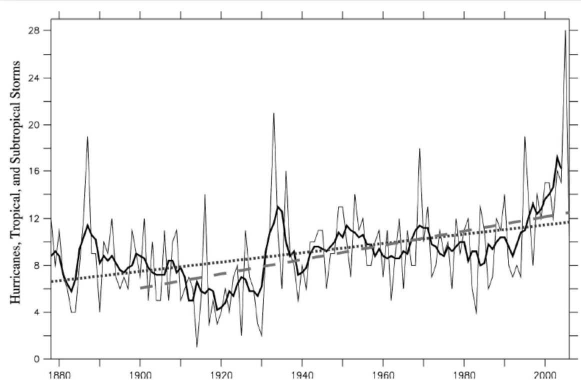


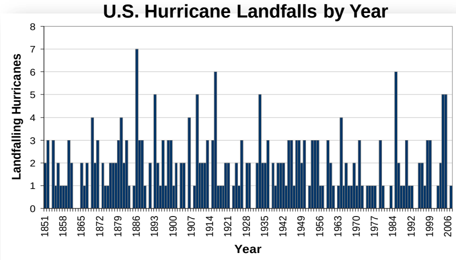
FIG. 1. Time series of unadjusted HURDAT Atlantic basin TC counts over the period 1878–2006. Black line shows the annual count of tropical and subtropical storms, and hurricanes in the HURDAT database. Dashed lines indicate the linear least squares trends computed over the periods 1878–2006 and 1900–2006.

Source: Vecchi, G. A. and T. R. Knutson, 2007: On Estimates of Historical North Atlantic Cyclone Activity. J. Climate, 21, 3580 - 3600

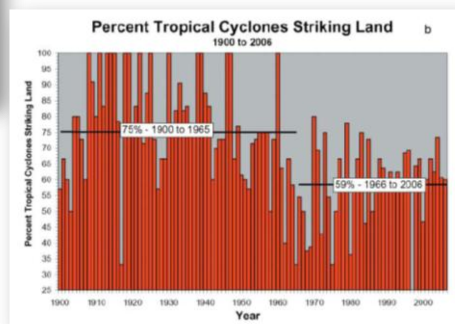
KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

The Landfall Paradox: Increase in Basin Storm Observations Has Not Resulted in Increase in U.S. Hurricane Landfalls

U.S. Hurricane Landfalls by Year



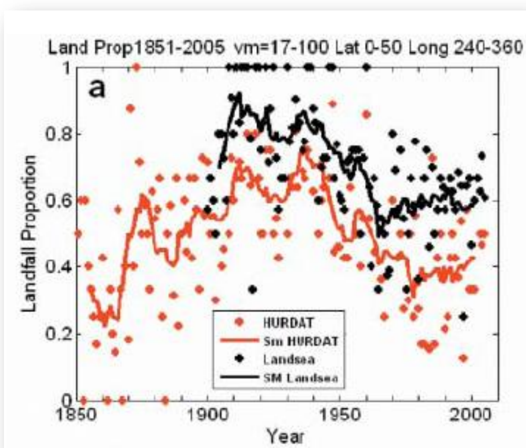
Source: Blake, E.S., E.N. Rappaport, C.W. Landsea, 2007: The Deadliest, Costliest and Most Intense United States Tropical Cyclones from 1851 to 2006 (and Other Frequently Requested Hurricane Facts). NOAA, Technical Memorandum NWS-TPC-5, 43 pp, and National Hurricane Center Tropical Cyclone Reports. Updated to 2007 by Karen Clark & Company.



Source: Landsea, C.W., 2007: Counting Atlantic Tropical Cyclones Back to 1900. EOS, Vol. 88, No. 18, pp. 197-208.

© 2009 Karen Clark & Company

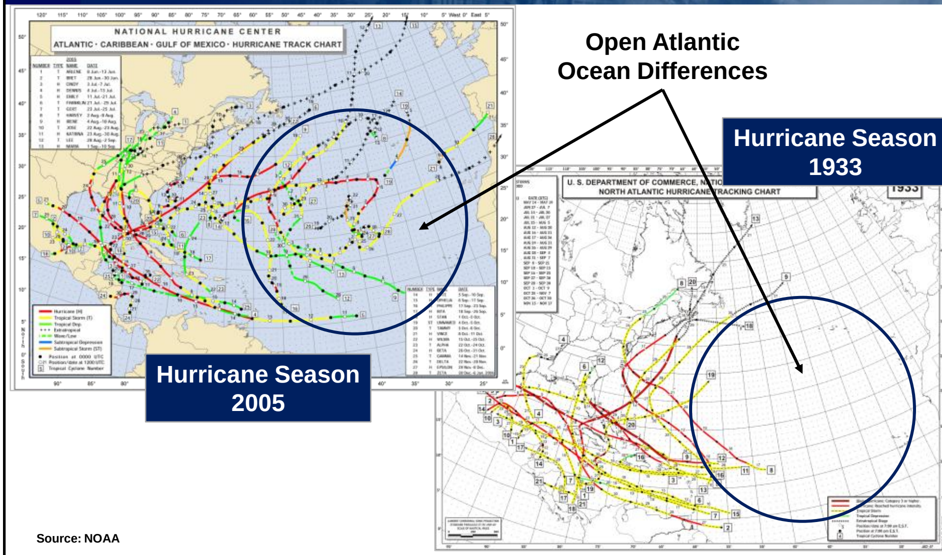
Some Scientists Have Argued that Climate Contributes to the Landfall Paradox



Source: Greg Holland.

© 2009 Karen Clark & Company

Other Scientists Have Argued this Landfall Paradox is Due to Advances in Detection Technology



Source: NOAA

KAREN CLARK & COMPANY

© 2009 Karen Clark & Company

Quotes from Scientific Papers Presented at the Catastrophe Modeling Forum October 2007

- **Kerry Emmanuel, MIT: "While there has been some advance in the theory of tropical cyclone intensity, the question of frequency is more vexing … a good theoretical understanding of the environmental control of storm frequency is lacking."**

- **Researchers from Georgia Tech: "The challenge to scientists is to assess the future risk in the face of incomplete data, imperfect models, and incomplete understanding."**

KAREN CLARK & COMPANY

© 2009 Karen Clark & Company

Estimates of Hurricane Activity from "Near Term" Models

Table 1: **Number of Atlantic Hurricanes**

	Long-Term Average	Actual	AIR	EQECAT	RMS
			Near Term Predictions		
2006	*5.9*	*5*	*8.4*	*8.0*	*8.4*
2007	*5.9*	*6*	*6.8*	*8.0*	*8.4*
2008	*5.9*	*8*	*6.8*	*8.1*	*8.4*
Total	*17.7*	*19*	*22.0*	*24.1*	*25.2*

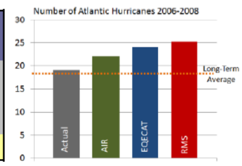
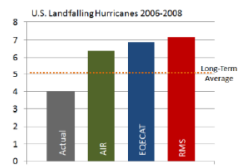


Table 2: **Number of U.S. Landfalling Hurricanes**

	Long-Term Average	Actual	AIR	EQECAT	RMS
			Near Term Predictions		
2006	*1.7*	*0*	*2.4*	*2.3*	*2.4*
2007	*1.7*	*1*	*2.0*	*2.3*	*2.4*
2008	*1.7*	*3*	*2.0*	*2.3*	*2.4*
Total	*5.1*	*4*	*6.4*	*6.9*	*7.2*

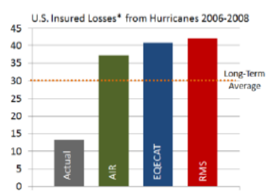


KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Estimates of U.S. Insured Hurricane Losses from "Near Term" Models

Table 3: **U.S. Insured Losses from Hurricanes ($ Billions)**

	Long-Term Average	Actual	AIR	EQECAT	RMS
			Near Term Predictions		
2006	*10*	*0*	*14.0*	*13.6*	*14*
2007	*10*	*0*	*11.6*	*13.5*	*14*
2008	*10*	*13.3*	*11.6*	*13.7*	*14*
Total	*30*	*13.3*	*37.2*	*40.8*	*42*



* $ Billions

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

An Even More Surprising Statistic

The period 1998 to 2007 was an *average* period with respect to catastrophe model average annual loss estimates – even with 2004 and 2005

Year	# Landfalls	Loss ($B)*
1998	3	4.2
1999	3	2.9
2000	0	-
2001	0	-
2002	1	0.5
2003	2	2
2004	5	25.1
2005	5	61.9
2006	0	-
2007	1	-
Average	2.0	9.7
Long-Term Average	1.8	10

Source: III, PCS

* Adjusted to 2007 dollars

© 2009 Karen Clark & Company

Catastrophe Risk Management Does Not Equal Catastrophe Models

- **Catastrophe models are only one source of information on potential catastrophe losses and should not be the sole source**
- **Best practices require intelligent use of models, data and other resources**
- **Best practices require an a priori view of catastrophe risk, model transparency and credibility, and exposure data quality**

KAREN CLARK & COMPANY
© 2009 Karen Clark & Company

Please Direct Questions and Requests for Additional Information to:

Glen Daraskevich
Senior Vice President

e: gdaraskevich@kcc.us.com
t: 617.423.2800 x204

© 2009 Karen Clark & Company